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TAN BARK AS A BOILER FUEL

By David Moffat Myers, New York
Associate Member

It is the object of this paper to give the chief characteristics of wet spent tan as a boiler fuel. It is believed that tan bark contains a larger percentage of moisture than any of the other moist fuels. It is perhaps safe, therefore, to assume that its correct treatment as a fuel may indicate to a certain extent the most efficient means of dealing with other moist fuels.

2 The writer has been engaged in testing, remodeling, operating and constructing steam plants depending partly or principally upon tan bark for their fuel; and in connection with this work the following tests and observations were made, not only to determine the value of the fuel, but principally to indicate the most favorable conditions for its complete combustion and to improve the economy of the plants visited.

PHYSICAL CONDITIONS

3 The nature of tan bark is too well known to require minute description, but it may be stated, as relating directly to its use as a fuel, that its condition in the fireroom varies with the method of its preparation for leaching, and its treatment in the leaches. Bark which has been finely disintegrated, and has been blown a long distance through a pipe or flue, will reach the furnaces almost in the state of a wet powder, difficult to burn. On the other hand, with less thorough disintegration and a shorter fan drive, the tan will be in larger pieces which allow a freer passage to the draft. The tan in the fireroom varies in temperature according to its final treatment in the leach house and according to the distance it is conveyed from the leach to the furnaces. Under good conditions it often reaches the fireroom at a temperature of 110 deg. fahr. The amount of moisture

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in the tan varies with the leaching process and usually runs from 62 to 70 per cent. Oak tan is easier to burn than hemlock because it is harder and does not become soggy and pack on the grates, but admits the draft more freely than the hemlock.

CALORIMETER TESTS

4 The calorific tests given in Table 1 were made by Dr. Henry C. Sherman of Columbia University, the samples of tan being dried before burning.

TABLE 1 CALORIFIC VALUES OF DRIED SPENT HEMLOCK TAN

Sample No.	B. t.u. per Pound	Sample No.	B. t.u. per Pound
1	9406	7	9519
2	9378	8	9450
3	9463	9	9504
4	9500	10	9850
5	9516	11	9472
6	9482	Average.....	9504

Note—Samples 7, 8 and 9 each contained about 6 per cent of oak tan.

EFFECTS OF LEACHING

5 Calorific tests were made to determine the effect of leaching on the fuel value of the tan, and it was found that the percentage of tannin left in the bark does not affect its calorific value per dry pound. As a check a further test was made, comparing a sample of leached bark and one of unleached bark. The result showed only a slight difference of heat units between the two and in fact a trifle more heat in the leached bark per dry pound. In other words it can be stated that the degree of leaching to which tan bark is subjected does not affect its fuel value, except inasmuch as actual weight is subtracted by the leaching process, so that a smaller quantity of fuel reaches the fireroom.

6 As regards the loss of weight due to leaching, 100 lb. of air-dry bark fed to the mill will produce 74.7 lb. of tan in the fireroom under good leaching conditions. This tan contains 65 per cent moisture, e. g., 100 lb. of air-dry bark ground at the mill will result in about 213 lb. of spent tan, containing 65 per cent moisture, in the fire-room; i. e., the weight of the spent tan is 2.13 times the weight of the bark ground.

MOISTURE

7 Ten of these samples contained moisture varying from 63.6 per cent to 68.27 per cent, the average moisture being 65.5 per cent. Many more moisture tests were made, but these ten samples are typical and represent about the average conditions in this respect. Taking the average calorific power of dried hemlock tan at 9500 B.t.u., and the average moisture at 65 per cent, and calculating the loss due to moisture, we have: Loss by moisture = $0.65[(212° - t) + 966 + 0.48\ (T - 212°)]$. For t we have the temperature of the moist fuel = 100 deg., and for T the temperature of the flue gases, which in tan burning averages about 500 deg. Substituting these values gives:

Moisture loss = $0.65\ (212 - 100) + 966 + 0.48(500 - 212)$ = 660 B.t.u.

8 Since a pound of fuel is 65 per cent moisture, 0.35 lb., or the dry amount, must evaporate 0.65 lb. moisture. The calorific value of 0.35 lb. of dry tan is 0.35 of 9500 B.t.u., or 3325 B.t.u., which is the total B.t.u. in a pound of moist fuel. Subtracting the moisture loss we have 3325 B.t.u. − 660 B.t.u. = 2665 B.t.u., as the available heat in a pound of fuel as fired.

TAN BARK COMPARED TO COAL

9 As previously deduced, the weight of the bark as ground × 2.13 = the weight of the spent tan. Therefore the available heat for boiler purposes obtained from a pound of average air-dry hemlock bark is 2.13 × 2665 B.t.u. = 5676 B.t.u. As compared to coal of 13,500 B.t.u., 1 ton of hemlock bark ground at mill = 0.42 tons coal.

CHEMICAL ANALYSIS

10 The chemical composition of dry tan is as follows:

	Per cent
Mineral ash	1.42
Hydrogen	6.04
Carbon	51.80
Oxygen	40.74
	100.00

This sample was hemlock tan containing 6 per cent oak tan. When dried at 110 deg. cent., it lost 66.77 moisture.

EVAPORATIVE TESTS

11 The actual evaporative power of tan was taken from the results of 22 complete boiler tests burning tan alone. Eight of these were thermal-efficiency tests.

12 Four complete thermal-efficiency tests were also made using both tan and coal for fuel. The above tests were conducted in accordance with the Am. Soc. M. E. code, and in different parts of the country, including the South, the East and the Middle West. The type of boiler in every case was the horizontal tubular. The furnaces varied considerably in design and economic results; but they were all of the Dutch oven type, set in front of the boiler; and all were fired from the top through feed-holes, with the exception of the furnace designed by the writer, the results and design of which will be described later. All the above tests were made under natural draft. Tables 2 and 3 show one of the 24-hr. boiler and furnace efficiency tests, selected to show what may be considered ordinary conditions and results in tan burning.

13 By designing and constructing a special furnace for the purpose the writer obtained a thermal efficiency of furnace and boiler of 71.1 per cent, burning hemlock tan, efficiency based on available heat of fuel. The principal features of this furnace, which was sub-

TABLE 2 BOILER TEST "X" TANNERY

DATA AND RESULTS OF EVAPORATIVE TEST ON BOILER NO. 6 TO DETERMINE HORSEPOWER DEVELOPED AND EFFICIENCY OF EXISTING METHODS AND CONDITIONS FOR BURNING WET SPENT HEMLOCK TAN AS FUEL FOR STEAM GENERATION.

Kind of fuel	Wet spent hemlock tan
Kind of furnace	Wide high oven, 2 rows firing eyes
Method of starting and stopping test	Alternate
Grate surface, square feet	92
Water heating surface, square feet	2089
Heating surface ÷ grate surface	22.7

TOTAL QUANTITIES

Date of trial	November 5 and 6, 1902
Duration of trial, hours	24

Weight of tan as fired, pounds	53,000
Percentage of moisture in tan	65.6
Total weight of dry tan consumed, pounds	18,232
Total weight of water fed to boiler, pounds	69,825
Factor of evaporation	1.1216
Equivalent water evaporated into steam from and at 212 deg., pounds	78,316

HOURLY QUANTITIES

Wet tan consumed per hr. pounds	2208
Dry tan consumed per hr., pounds	1823
Water evaporated per hr., pounds	2909
Equivalent evaporation per hr., from and at 212 deg., pounds	3263

AVERAGE TEMPERATURES, PRESSURES, ETC.

Steam pressure by gage, pounds	70.25
Temperature feed-water entering boiler	126.5
Temperature escaping gases from boiler	471
Force of draft between damper and boiler, inches water	0.39
Temperature outside air	64
Temperature of tan as fired	83

HORSEPOWER

Horsepower developed	94.6
Rated horsepower, at 15 sq. ft	139
Percentage rated horsepower developed	68

ECONOMIC RESULTS

Water evaporated under actual conditions per lb. tan as fired, pounds	1.32
Equivalent evaporation from and at 212 deg. per lb. tan as fired, pounds	1.48
Equivalent evaporation from and at 212 deg. per lb. dry tan, pounds	4.30

EFFICIENCY

Calorific power of dry tan per lb., British thermal units	9463
Percentage moisture in tan as fired	65.6
Available heat in 1 lb. of wet tan as fired, after subtracting loss due to evaporating moisture, British thermal units	2443
Efficiency of boiler including furnace, based on available heat in fuel, per cent	58.2
Efficiency of boiler including furnace, based on total heat in fuel, per cent	43.9

FIRING

2 rows of eyes, 3 eyes in each row. Eyes were fired according to regular method employed at this tannery, i. e., they were refilled as they burned low, a large amount of tan being fired each time. 51 eyes were fired during the 24-hr. test.

TABLE 3 FLUE-GAS ANALYSIS

DAMPER WIDE OPEN

No.	TIME	CO_2 %	O %	CO %	FIRING
1	9 : 45	10.8	7.5	....	30 minutes after
2	10 : 21	4.2	12.3	....	30 minutes after
3	11 : 48	11.5	7.0	....	14 minutes after
4	12 : 29	5.0	15.0	....	22 minutes after
5	1 : 37	4.6	15.1	0.5	While firing
6	2 : 06	5.0	13.0	0.3	14 minutes after
7	3 : 05	9.2	....	....	40 minutes after
8	4 : 08	9.8	8.4	.....	While firing
9	5 : 30	12.6	6.6	0.1	5 minutes after
10	6 : 20	12.6	7.0	0.5	26 minutes after
11	6 : 55	11.6	7.4	0.2	25 minutes after
12	7 : 50	13.0	6.0	0.6	20 minutes after
13	8 : 55	13.0	7.2	0.1	While firing
14	10 : 09	11.0	9.1	...	6 minutes after
15	11 : 07	12.5	6.9	0.1	29 minutes after
16	12 : 23	11.5	7.5	0.8	23 minutes after
17	1 : 07	7.6	11.8	1.1	67 minutes after
18	2 : 10	12.5	7.7	0.0	24 minutes after
19	2 : 50	6.0	13.5	...	20 minutes after
20	4 : 00	4.3	15.7	...	58 minutes after
21	5 : 30	3.0	16.4	0.3	While firing
22	6 : 02	11.0	8.8	0.0	27 minutes after
23	6 : 37	9.0	9.8	0.0	6 minutes after
24	7 : 35	8.7	11.0	0.2	9 minutes after
Average	.....	9.2	8.2	0.32	

sequently installed in a number of plants, were: *a* Large combustion space over the burning fuel. *b* Automatic stoking with rotating comb shafts. *c* Oppositely inclined grate surfaces converging downward to a set of shaking and dumping grates. *d* Drying on dead plates over which fuel passed before receiving air supply. *e* Concentrated draft from opposing grate surfaces to a focus of combustion, caused by parallel spacing of longitudinal flat grate bars with beveled edges. *f* Reverberating draft action resulting from concentrated draft-currents and the curvature of the arch, thus directing flames back upon dead plates. The full results of a test on this furnace are given in Table 4.

EFFECT OF PRESSING AND BURNING MIXED WITH COAL

14 It was desirable to learn the exact economic effect of burning coal with pressed tan and also the result of pressing the tan to eliminate some of the moisture. For these purposes three thermal-

TABLE 4 BOILER TEST AUTOMATIC STOKER FURNACE DESIGNED BY THE WRITER

DATA AND RESULTS OF EVAPORATIVE TEST ON BOILER NO. 1 TO DETERMINE HORSEPOWER DEVELOPED, AND EFFICIENCY OF BOILER WITH AUTOMATIC TAN STOKER

Kind of fuel	Wet spent hemlock tan
Kind of furnace	Automatic stoker
Method of starting and stopping test	Alternate
Grate surface, square feet	61.5
Water heating surface, square feet	1795

TOTAL QUANTITIES

Date of trial	August 14, 1903
Duration of trial, hours	12
Weight of tan as fired, pounds	18,600
Percentage moisture in tan	65.3
Total weight of dry tan consumed, pounds	6449
Total weight of water fed to boiler, pounds	33,004
Factor of evaporation	1.085
Equivalent water evaporated into steam from and at 212 deg., pounds	35,809

HOURLY QUANTITIES

Wet tan consumed per hr., pounds	1550
Dry tan consumed per hr., pounds	537
Water evaporated per hr., pounds	2750
Equivalent evaporation per hr. from and at 212 deg., pounds	2984

AVERAGE TEMPERATURES, PRESSURES, ETC.

Steam pressure by gage, pounds	43
Temperature feed-water entering boiler	155
Temperature inside furnace	1100
Temperature in combustion chamber	1475
Temperature gases escaping from boiler	493
Temperature outside air	71
Temperature of air entering ash pit	78
Temperature of tan as fired	101
Force of draft between damper and boiler, inches water	0.4

HORSE POWER

Horsepower developed	86.5
Rated horsepower of boiler at 15 sq. ft., per h.p.	120
Percentage rated horsepower developed	72.1

ECONOMIC RESULTS

Water evaporated under actual conditions per lb. of tan as fired, pounds	1.77
Equivalent evaporation from and at 212 deg. per lb. of tan as fired, pounds	1.93
Equivalent evaporation from and at 212 deg. per lb. of dry tan, pounds	5.55

EFFICIENCY

Calorific value of dry tan per lb., B.t.u. 9850
Percentage of moisture in tan as fired 65.33
Available heat per lb. of tan as fired, B.t.u. 2623
Efficiency of boiler, including furnace, based on available heat in fuel, per cent 71.1
Efficiency of boiler, including furnace, based on total heat in fuel, per cent ... 54.4

FIRING

Firing was even and continuous with automatic stoking. Bed of fuel maintained on grates was about 9 in. thick.

TABLE 5 FLUE GAS ANALYSES

DAMPER OPEN

No.	TIME	CO_2 %	O %	CO %
1	2 : 25	11	7.5	0
2	4 : 30	12.8	5.6	0
3	7 : 15	12	7.8	0
4	9 : 05	13	6.2	0
5	11 : 10	13	6.4	0
Average		12.4	6.7	0

TABLE 6 ANALYSIS OF SPENT BARK

CHEMIST'S NO. S.-736, ANALYZED AUGUST 17, 1903

	%		%
Moisture	65.33	Non-tannins	2.35
Total solids	5.11	Available tannin	1.89
Total soluble solids	4.24	Reds	0.87

efficiency tests were conducted, all on the same boiler and furnace, the conditions as far as possible being the same in all tests, and the furnace operated by the same firemen. The furnaces and boiler were of the general type already referred to. The combustion chamber under the boiler differed by having a system of air admission through the bridge wall. The opening in the wall for admitting air to this system was set $\frac{1}{4}$ open in the first test and remained so in all three tests, each of ten hours' duration. An effort was made in each of the two tests without coal to equal the boiler output of the test in which coal was used; but as shown below this could not be done.

15 The furnace arch was equipped with two rows of firing-eyes of three eyes each, and two eyes on the same side of the furnace were usually fired at a time. The firing was heavy, the cone of tan nearly reaching the arch each time after firing. The furnace had a grate surface of 11 ft. 4 in. by 7 ft. 0 in. = 79.3 sq.ft., and the perpendicular distance from the grate surface to the highest point of the arch inside was 48 in. The boiler was 6 ft. by 18 ft. and contained 2089

TABLE 7 COMPARATIVE RESULTS OF THREE TESTS

	Test No. 1	Test No. 2	Test No. 3
Thermal efficiency of boiler including furnace, based on available heat in fuel, per cent	63.4	59.4	59.
Evaporation from and at 212 deg. per lb. tan as fired, pounds	1.98	1.90	1.65
Evaporation from and at 212 deg. per lb., dry tan, pounds	5.43	4.71	4.54
Percentage rated h.p. developed	135.5	92.	72.4
Type of furnace		wide and high	
Heating surface ÷ grate surface	26.3	26.3	26.3
Number of firing-eyes	6	6	6
Depth of combustion chamber, inches	48	48	48
Kind of firing	deep	deep	deep
Firing intervals, minutes	18.8	18.8	19.4
Kind of fuel	pressed tan and coal	pressed tan	unpressed tan
Moisture in tan, per cent	60.4	59.6	63.6
Steam pressure, pounds	76	74	63.4
Temperature feed-water	163	160	161
Flue temperature	561	486	445
Force of draft in uptake, inches water	0.51	0.49	0.43
Duration of trial, hours	10	10	10
Flue-gas analyses, averages per cent CO_2	13.8	10.9	10.5
Per cent O	4.9	7.8	8.6
Per cent CO	0.15	0.93	0.68

sq.ft. heating surface, the ratio of heating surface to grate surface being 26.3 to 1.

16 Nine flue-gas analyses were made during test No. 1, seven in each of the following tests, and the averages of these results are given in Table 7 which gives the most essential results of the three tests.

17 The results of this series of tests show:

a That the burning of coal with pressed tan increased the thermal efficiency from 59.4 per cent to 63.4 per cent.

b That the burning of coal with pressed tan increased the boiler output from 92 per cent of rated capacity to 135.5

per cent of rated capacity, the force of draft differing by only 0.02 in. water-gage.

c That the degree of combustion as indicated by the amount of CO_2 was raised from 10.9 per cent CO_2 with pressed tan to 13.8 per cent CO_2 with pressed tan and coal.

d That the flue temperature was increased from 445 deg. with unpressed tan and 486 with pressed tan to 561 deg. with pressed tan and coal.

e That the thermal efficiency based on available heat obtained with pressed tan was 59.4 per cent as compared to 59 per cent with unpressed tan.

f That the burning of pressed tan gave a boiler output of 92 per cent rated capacity as compared to 72.4 per cent with unpressed tan, the draft being only 0.04 in. water-gage stronger in the test of greater capacity.

g That since the thermal efficiency was practically the same with both pressed and unpressed tan the principal advantage of pressed over unpressed tan in this particular case lies in the intrinsically greater calorific value of the pressed tan owing to its reduced moisture. In this particular case, in which the unpressed tan contained 63.6 per cent and the pressed tan 59.6 per cent moisture, the actual gain in available heat-units was 4.5 per cent over the unpressed tan or $1\frac{1}{8}$ per cent gain in heat value for each per cent decrease in moisture.

TAN PRESSES

18 Tan presses for reducing the moisture in actual practice result in a total economic gain of only about 7 per cent; and against this must be charged the power to run them, maintenance, repairs and often the disadvantage of noise and vibration in the fireroom.

19 The question of installing a press must be determined principally by local conditions, such as amount of tan available, amount and proportion of coal used and its cost, intelligence of labor, average moisture in the tan as delivered to the fireroom, design of furnace and grate, cost of changing such design, etc. Especially when the firing is poor a press is of much value, for certain firemen who can get excellent steaming with pressed tan cannot raise steam with unpressed tan. When a press is introduced for tan burning and the moisture is reduced, the rate of combustion with given grate and draft

is increased. Therefore to burn the pressed tan in the time required to burn the wet tan, it is necessary to reduce the grate surface proportionately.

20 For example, two complete 24-hr. evaporative tests were made on the same boiler and furnace, with the same firemen and with the same conditions as nearly as possible, the first with unpressed and the second with pressed tan, with the following results:

Test No. 1, without press, 64.4 per cent moisture, consumption 14,565 lb. dry tan with 0.42 draft.

Test No. 2, with press 60.4 per cent moisture, consumption 19,879 lb. dry tan with 0.38 draft.

Thus the rate of combustion on the same grate was increased 36.5 per cent. (It may here be noted that the boiler-horsepower developed in the first test was 89.3 h.p., and in the test with pressed tan 116.8 h.p.)

21 Therefore in this case to burn the tan in the same time as formerly it would be necessary to reduce the grate surface about 27 per cent. This is based on the above drop in moisture from 64.4 per cent to 60.4 per cent, or 4 per cent. The drop in moisture with fair pressing will run between 6 and 7 per cent, representing a total gain of available heat of 7 to 8 per cent. With good pressing the grate surface may be properly reduced one-third.

22 There have been cases of failure with pressing the tan simply because the precaution of reducing grate surface was not taken. Tannery superintendents have said, "We have tried presses and had to throw them out, because the tan would not last throughout the day, and we had to use more coal to make up the deficiency." The point here is that a tannery will almost invariably consume or waste every pound of steam its boilers will supply. With the press in operation the steaming was increased proportionately as long as the tan "lasted," no provision being made to correct the grate surface, and consequently the result would be exactly as stated by the superintendent. This has led to, or confirmed, the erroneous opinion held by some that the moisture in tan aids its combustion.

EFFECT OF SMALL COMBUSTION SPACE OVER THE FIRE

23 A special test on a low-arched furnace was made to obtain comparison with high arches. A furnace containing nine feed-holes,

and having a height from arch to grate of 26 in., was tested, with the results shown in Table 8.

TABLE 8 RESULTS OF TEST ON LOW-ARCHED FURNACE[1]

Efficiency of boiler and grate, per cent	26.4
Evaporation from and at 212 deg. per lb. tan as fired	0.63
Percentage rated h.p. developed	39
Heating surface ÷ grate surface	28
Depth combustion chamber under boiler	3′6″
Intervals between firing, minutes	6.3
Kind of tan	Hemlock
Percentage moisture in tan	67.2
Temperature flue-gases	422
Draft at damper, inches	0.37

24 These miserable results are to be attributed to the low arch and the consequently inadequate combustion-space between the fuel and the arch of the furnace. Owing to this small space the velocity of draft and gases was very high, thus removing the volatile fuel-gases from the furnace before their combustion could be fairly begun, and allowing no heating or mixing action in the furnace, and when they struck the boiler the combustion was checked or stopped.

25 The worst evaporative results ever obtained on various designs of higher furnaces, on tan alone and with poor firing are at least 100 per cent better than this, and these other furnaces ran from 3 ft. 0 in. to 5 ft. and 6 ft. high; it is perhaps significant that the highest thermal efficiency was obtained in the furnace with the greatest amount of free combustion space between the fuel bed and the top of the arch.

26 During recent years tanneries have been using more extracts and less bark for their liquors. At the same time a greater amount of machinery has been introduced and it has been found beneficial to use more heat in leaching. All these changes have resulted in greater steam requirements and less spent tan bark for its generation. Therefore more coal is required in the boiler room and stricter economy of fuel is necessary.

BURNING A MIXTURE OF TAN AND COAL

27 Among other methods of burning the two fuels, the ordinary coal-burning setting has been tried. The grates are usually of the shaking variety and are set directly under the boiler, and generally only 24 in. to 30 in. beneath the shell of the boiler. The coal and tan

[1]Average flue-gas analyses: CO_2, 4.3 per cent; O, 11 per cent; CO, 20 per cent.

are fired alternately by hand. Owing to the large volume of tan as compared to its heating value (spent tan weighs about 33 lb. per cu. ft.) the fire doors have to be opened very often, thus admitting a great excess of cold air to the fire. The fire bed has a strong tendency to burn through in spots and form blowholes. The temperature-retaining effect of the Dutch oven arch is lost, and instead, the fuel gases come into direct contact with the shell of the boiler, which cools them before combustion is fairly under way. The result of every such case the writer has observed has been a dull, smoky fire of greatly varying temperature and never good combustion. In a certain plant where this method was thoroughly tried out, it proved so unsuccessful that it was discontinued and the grates were replaced by Dutch ovens in which the mixture of tan and coal was burned, the fuels being mixed before firing.

28 The above illustration affords a good comparison of combustion with and without a brick arch over the fire bed with hand firing, and goes to show that a brick or refractory arch is a necessity for good combustion, when the two fuels are so related in quantity that their heat values are about equal. As a further demonstration, experiments with automatic stoking may be cited. The mixed fuel was fed into a chain-grate stoker operating on induced draft. This was done under the most favorable conditions possible and under the supervision of an engineer representing the chain-grate company, with the assistance of the writer. The steam pressure and the furnace temperature dropped rapidly, and it was soon necessary to eliminate the tan and feed coal alone, to prevent the fire from going out. Experiments with different methods of mixing and feeding the two fuels all resulted in killing the fire.

29 Like experiments were conducted on a Detroit stoker set in front of boiler and having a brick arch completely over the fire. No scientific tests were conducted, but the mixed fuel easily carried the load formerly carried by the coal, it being necessary only to increase the speed of the stoker. The steam pressure was increased and as far as the eye could detect there was not the slightest decrease of furnace temperature, the combustion being clear and to all appearances excellent.

30 From these experiments it seems entirely safe to state that for efficient combustion of a mixture of tan and coal in ratio by weight of 5.2 to 1 a refractory arch over the greater part of the fire, and preferably over the entire fire-bed, is not only advisable but necessary. It follows that tan bark of the usual moisture and heat content can-

not be burned without the application of a refractory arch, or some device of similar function, such as a large combustion chamber lined with refractory material.

31 Wood is sometimes burned in combination with tan in the same furnace. Good results are obtained when the wood is ground to about the same fineness as the tan, when it is known in the sawmill districts as "hog feed." When wood in slab or log form is burned in the same furnace with tan the results naturally are usually very poor, owing to blowholes formed in the fire bed and consequent large excess of air. A case of this description came under the writer's observation. "Edgings" from a nearby sawmill cost less than coal per 1000 B.t.u., and it was the custom to fire the edgings by hand into the front fire doors of the tan furnaces, the tan being fired from above in the usual manner. A large amount of labor was required and the furnace fronts required constant repairing. By substituting coal for the wood in this case, and mixing with the tan before firing, a very good saving was effected in fuel, labor and repairs.

32 In regard to draft for tan burning, in 26 evaporative tests on tan-burning furnaces the average force of draft between boiler and damper was 0.45 in. water gage.

33 The average draft, in 13 tests on tan where less than the rated capacity of the boiler was developed, was 0.42 in. water gage between boiler and damper.

DRAFT AND GRATE SURFACE

34 The average draft, in 12 tests on tan where rated capacity up to 60 per cent over-capacity was developed, was 0.47 in. water gage. This comparison is significant only in a very general way, owing to the great variety of ratios of heating to grate surfaces in the different tests, and the different methods and time intervals of firing. The highest force of draft found in any case between damper and boiler with chimney draft, furnaces burning tan only, was 0.63 in., and the lowest 0.32 in.

35 The lightest draft with which rated capacity was obtained was 0.32 in., and in this case the ratio of heating surface to grate surface was 21.8 to 1. In the test where 160 per cent rated capacity was developed the force of draft was 0.51 in. and the ratio of heating surface to grate surface was 19.3 to 1. The greatest ratio of heating surface to grate surface which developed full rated capacity was 29.9 to 1, giving 110 per cent rated capacity with force of draft in uptake

0.42 in. The firing in this case was excellent with intervals of 7.4 min.

36 Owing to space required, facility in cleaning fires, minimum radiation from furnace and expense of building and repairing, it is desirable to make the furnace grate area as small as possible and still conform to capacity requirements. It is therefore necessary to know the boiler-horsepower developed per square foot of grate surface. The force of draft, method of firing and ratio of heating surface to grate surface, are all factors in this result, also the moisture in the tan bark. Table 9 gives the most important factors with results of nine actual tests.

TABLE 9 RESULTS OF NINE TAN-BURNING TESTS

Test No.	Tan	Moisture %	Draft Inches	H.S. / G.S.	Firing Intervals Minutes	B.H.P. per sq. ft. G. S.
1	Oak	0.53	0.63	29	15	2.35
2	Hemlock	....	0.51	19.3	8	2.07
3	Oak	0.64	0.58	29	5	2.37
4	Oak	0.64	0.61	34.8	....	1.53
5	Hemlock	0.65	0.61	17.4	50.8	0.92
6	Hemlock	....	0.32	21.8	5.2	1.51
7	Hemlock	0.68	0.39	29.9	7.4	2.34
8	Hemlock	0.64	0.42	22.7	30	0.97
9	Hemlock	0.65	0.40	29.2	Continuous	1.31

37 Inspection of this table shows that one factor above all the others influences the b.h.p. developed per square foot of grate, and this factor is the method of firing. Thus the tests in which the time intervals between firing are small show a marked increase in b.h.p. per square foot of grate. This test is upheld by many other tests of the writer. From the table we may take the following average results:

For oak tan with 60 per cent moisture, 0.61 in. draft, in uptake of horizontal tubular boiler, and good firing of 15 min. or less between firing, 2.08 b.h.p. per sq.ft. of grate surface.

For hemlock tan with 65½ per cent moisture, 0.44 in. draft in uptake of horizontal tubular boiler, and good firing of say 17 min. or less between firing, 1.52 b.h.p. per sq. ft. of grate surface.

GRATE SURFACE FOR COAL AND TAN

38 The above results are for burning tan alone. At the present time, however, it is very general practice, as previously set forth, to burn coal with the tan. The best results in most cases are obtained when the coal is mixed evenly with the tan, and the mixture burned in a Dutch oven with shaking and dumping grates. This practice modifies the boiler-horsepower per square foot of grate. The grate surface often allowed is at the rate of about 3¼ b.h.p. per sq. ft. of grate surface, the ratio of heating surface to grate surface ranging from 50 to 1 to 33 to 1.

TABLE 10 RESULTS OF TESTS OF BURNING COAL WITH TAN IN DUTCH OVENS

Test	Tan	Grates	Tan Moisture %	Uptake Draft	H. S. G. S.	Firing Intervals Minutes	Weight of Coal to Weight of Tan as Fired	B.H.P per Sq. Ft. of Grate
a	Hemlock	Shaking	68	0.40	33.5	20	1 to 8.9	2.52
b	Hemlock	Stationary	60.4	0.51	28.1	19	1 to 6.1	2.53
c	Hemlock	Stationary	66.7	0.67	37.3	6.3	1 to 46.4	2.70
**d*	Oak	Shaking	67.4	0.7	29.4	47	1 to 2.9	2.66
e	Hemlock	Stationary	66.5	1.05	32.8		1 to 22.8	1.33

*Tubular Boiler, coal fired independently in front doors of double arched tan furnace. The 47-min. interval refers to the tan only.

39 Of course, as with tan alone, the development per square foot of grate depends upon the same factors, with the additional factors of the proportion of coal mixed with the tan, and the B.t.u. and character of the coal. The figures in Table 10, selected at random, show the results in terms of b.h.p. per square foot of grate surface obtained in actual tests of burning coal with tan in Dutch ovens. It is of interest here to note that when the ratio of weight of coal to weight of tan as fired is 1 to 5.2, then the heat developed by each fuel is practically the same. This is figuring on 13,000 B.t.u. coal, and "tan as fired" containing 2500 B.t.u. available heat, which is good average value.

40 In further reference to draft, a test which showed excellent results was made on a plant operating on induced fan draft. A small proportion of coal was used in the tan furnaces and a thermal efficiency of 66.1 per cent was found under regular working conditions, the CO_2 in the flue gases averaging nearly 12 per cent. The writer has also observed an oak tan burning furnace operated temporarily on fan

draft with closed ashpit. The combustion was apparently very good; a hot fire was maintained, but additional care was required to keep blow-holes from forming on the grates.

41 A reliable report has also been obtained on the installation of a steam-induced forced-draft system, applied under the grate of a tan-burning furnace. According to the report, the steam used for the draft condensed on the grate bars, with low temperature due to contact with the large mass of wet tan, and the concern that made the installation after considerable experimenting removed the appliance and gave up tan burning.

GRATES

42 Grates for tan burning are made in different patterns, but usually contain from 20 per cent to 30 per cent air space, the actual opening between the bars being $\frac{3}{16}$ in. to $\frac{1}{4}$ in. Larger spaces than these allow the tan to fall through into the ashpit. A shaking grate is hardly necessary for burning tan alone, owing to the small percentage of ash. No clinker is formed, only a very fragile crust on the grate obtains in three or four hours. In some cases fires are cleaned only once in 12 hrs. with good results. Unlike a coal fire, a tan fire should be shaken or disturbed very little. If a slice bar is used on a brightly burning tan fire, dense smoke results and the flame is killed for some time.

43 The temperature in the throat of a properly designed tan furnace, burning tan alone, will reach 1500 deg. fahr.

44 The depth of fuel on the grate varies with the design of the furnace and the method of firing. In ordinary practice the tops of the cones of tan directly beneath the firing eyes vary from 2 ft. to 5 ft. above the grate surface, while the depth of tan where the cones meet will be from 6 in. to 18. in., depending on the design and firing of the furnace.

45 When spent hemlock tan forms a cone from the conveyor-discharge on the fireroom floor it forms an angle of slide of about 55 deg. to the horizontal. Inside a hot furnace, however, this angle is about 45 deg., and in laying out a tan furnace the latter angle is used in figuring the distribution of fuel on the grate. The angle of slide of tan on a sloping grate is 39 deg. to 41 deg., and these angles were used in designing the automatic tan furnace referred to previously.

46 Among other experiments with this fuel the writer has made

tests to compare results of double settings with single settings. By double setting is meant a setting so arranged that two furnaces discharge their gases into a common combustion chamber beneath two or more boilers. Tests showed no tangible results in favor of either method as regards evaporation or fuel economy. It is possible however to imagine a case where the fire in a furnace might be in poor condition, when if the setting were a double one, the second furnace might maintain in the common combustion chamber a temperature sufficiently high to ignite and burn fuel gases discharged from the dull fire which otherwise would escape unburned. It is the opinion of the writer, however, that owing to the impossibility of laying off a single boiler for cleaning or repairs, a double setting is less desirable than a single setting. Furthermore, good firing and handling would in any case offset any possible advantage of the double setting.

47 The combustion of tan, as indicated by flue-gas analyses made with an Orsat apparatus, compares most favorably with the combustion of coal in factory plants where the same amount of attention is paid to the boiler room. In fact, the percentage of CO_2 runs higher than in the ordinary coal-burning plant. For instance, the average CO_2 of 17 evaporative tests on different tan-burning furnaces was 11.3 per cent; the lowest average CO_2 in any of the tests was 4.3 per cent, which represented unusually and abnormally poor conditions; and the highest average CO_2 in any one of them was 16.9 per cent. The CO averages about 0.5 to 0.6 per cent and ranges from practically zero up to 2 per cent.

SUMMARY

48 The following statements concerning tan bark as a boiler fuel have been demonstrated by the foregoing data and confirmed by constant checking in actual practice:

49 *Moisture.* In condition for firing, wet spent hemlock tan usually contains close to 65 per cent of moisture.

50 *Available B.t.u.* Bomb calorimeter tests on many samples of spent hemlock tan give an average value of about 9500 B.t.u. per lb., sample being dried before burning. The available heat per pound as fired, after subtracting moisture loss, is about 2665 B.t.u.

51 *Ratio weights.* Since the weight of the spent tan in the fire room is 2.13 times the weight of bark ground at the mill, 1 lb. of ground bark produces an available heat value of 5676 B.t.u. Hence,

as compared to coal of 13,500 B.t.u., one ton of hemlock bark is equivalent to 0.42 ton coal.

52 *Effect of leaching on B.t.u.* The heat value of spent hemlock tan is not affected by the degree of leaching, except inasmuch as the actual weight is affected.

53 *Chemical composition.* The chemical composition of hemlock tan (sample containing 6 per cent of oak) was:

$$C = 51.8, H = 6.04, O = 40.74, \text{Mineral ash} = 1.42 \text{ per cent}$$

As a fuel analysis this is of interest as regards the small amount of ash and the large amount of oxygen.

54 *Boiler tests.* The actual operation of tan bark as a fuel is shown by complete boiler tests made under working conditions, records of which are given above.

55 *Improved efficiency.* A considerable improvement in efficiency was produced by a specially designed furnace providing automatic feeding, large combustion space over fuel and special draft admission.

56 *Tan Presses.* The use of presses for reducing the moisture in the tan before firing may be good economy if the amount of tan compared to the amount of coal used is considerable, and providing the grate surface is properly reduced to meet the demands of the more rapid combustion. In practice the grate surface is sometimes reduced one-third on the introduction of tan presses.

57 Under usual tan-burning conditions the total gain in available heat from the use of a press is about $1\frac{1}{8}$ per cent for each per cent drop of moisture content, and this drop rarely exceeds 7 per cent, i. e., a reduction of moisture from say 65 to 58 per cent.

58 The writer is of the opinion that the combined boiler and furnace efficiency would naturally rise considerably when tan presses are used, owing to increased furnace temperature and better combustion, although as shown by Table 7 the thermal efficiency was raised only from 59 per cent to 59.4 per cent, the moisture in the tan being 63.6 per cent and 59.6 per cent in the two tests respectively. This may be explained, at least partially, by the fact that the grate surface was not reduced for burning the pressed tan.

59 *Addition of coal.* As a result of special comparative tests, made under similar conditions on the same furnace and boiler, the addition of about one pound of coal to six of pressed tan increased the combined furnace and boiler thermal efficiency from 59.4 per

cent to 63.4 per cent. The addition of coal also resulted in raising the average CO_2 in the flue gases from 10.9 to 13.8 per cent. The percentage rated capacity of the boiler was increased from 92 per cent (without coal) to 135.5 per cent with coal.

60 Although the above precise statements were obtained from a single pair of accurate tests, the writer's subsequent experiences in many plants confirm the results as generally typical; and it may be safely stated that under usual working conditions the addition of coal to tan produces a decided increase in degree of combustion and a consequent rise of thermal efficiency. The increase of boiler output attending the use of coal with tan is also a factor of economy not to be disregarded.

61 *Ample combustion space.* One of the most important factors, in designing furnaces for tan-burning, is that of ample combustion space. In usual tan-burning practice this means a high arch over the furnace. Low-arched furnaces are conducive to bad combustion, whereas furnaces providing an arch at a considerable height above the fuel on the grates give decidedly better combustion and higher efficiency. (See tests and discussion, par. 23 *et seq.*)

62 *Refractory arch.* A refractory arch or similar combustion arrangement is necessary for the economic combustion of tan. Tan in its usual condition cannot be burned in a common coal-burning setting without an arch separating the fire from the cooling surface of the boiler shell or tubes. Even when tan is enriched with coal to a point where the two fuels form equal heating values (about 1 lb. coal to 5.2 lb. wet spent tan) good combustion cannot be obtained in an ordinary coal setting. This holds true both for hand-firing and automatic stoking. (See tests and discussion, par. 27 *et seq.*)

63 *Draft.* The force of draft required in general practice for tan burning is somewhat higher than that required for producing the same boiler output with bituminous coal. No definite figures can be given for force of draft as related to tan burned per square foot of grate surface, owing to the widely varying designs of furnaces and methods of firing. It may be stated, however, that for full capacity not less than $\frac{1}{2}$-in. draft should be provided for in the uptake of a horizontal tubular boiler, when the boiler is set so that the gases flow under the shell and through the tubes directly to the stack or breechen.

64 *Horsepower per square foot of grate.* The boiler-horse power obtainable per square foot of grate surface, depending upon the rate of combustion of the tan, is an extremely variable quantity; but aver-

aging the results of nine typical boiler tests it may be said that under usual conditions for oak tan the boiler-horsepower per square foot of grate is about 2.08; and for hemlock tan, 1.5 boiler-horsepower per square foot of grate is an average figure. As demonstrated by results of tests given in Table 9, the one factor which above all others influences the boiler output per square foot of grate is the method and comparative excellence of the firing, very short firing-intervals producing the higher output results.

65 *Horsepower with coal and tan.* When coal is burned in the same furnace with the tan the development per square foot of grate varies of course with the richness of the mixture and with the other usual conditions, and it is best in designing furnaces for any particular plant to use the results of tests made under similar conditions. In four cases out of five selected at random the boiler-horsepower per square foot of grate was 2.5 to 2.7.

66 *Draft area and air spacing.* Grates for tan burning provide 20 to 30 per cent draft area and the spacing is from $\frac{3}{16}$ in. to $\frac{1}{4}$ in.

67 *Clinker and ash.* Tan forms no hard clinker, only a light fragile crust, and a very small amount of ash (less than $1\frac{1}{2}$ per cent based on dry matter), and a shaking grate is unnecessary except when coal is fired with the tan.

68 *Furnace temperature.* Excellent combustion of tan has given a temperature of 1500 deg. fahr., in the throat of the furnace.

69 *Single vs. double setting.* As a result of comparative tests made on single vs. double settings for tan burning, the writer believes that the single setting should have the decided preference. A possible though not a decided improvement in combustion is sometimes obtainable with the double setting, but this is more than offset, especially in the small plant, by the advantages of convenience for cleaning, repairs and adaptation to load given by the single setting.

70 *Use of wood with tan.* When wood is used as a supplementary fuel to tan and fired in the same furnace, the best results are obtained by first grinding the wood to the size known as "hog feed." The firing of wood in log or slab form is disastrous both to the furnaces and to combustion.

71 *Flue gas analyses.* Basing comparison on flue gas analyses, tan burns with a higher combustion than coal, under equally favorable conditions. The large amount of moisture in the tan produces a comparatively low furnace temperature, even with good chemical combustion, and acts against an equally high combined efficiency of furnace and boiler.

72 The highest thermal-efficiency test obtained gave 71.1 per cent efficiency (on boiler and furnace, based on available heat in tan), and flue-gas analyses during this test averaged 12.4 per cent CO_2. The approximate relation of CO_2 to efficiency as obtained under actual

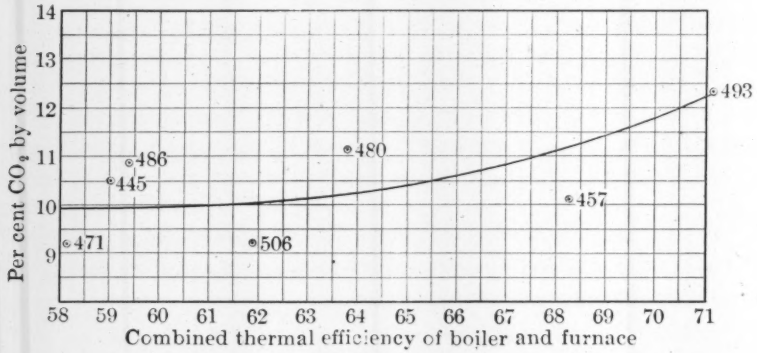


FIG. 1 CURVE SHOWING RELATION OF CO_2 TO EFFICIENCY IN TESTS ON TAN ALONE

running conditions is shown by the curve, Fig. 1, which was plotted from seven thermal efficiency tests made on various designs of furnaces burning tan alone. The figure given at each point plotted is the temperature of the escaping gases during the test.

THE BEST FORM OF LONGITUDINAL JOINT FOR BOILERS

By F. W. Dean, Boston, Mass.
Member of the Society

It has been generally accepted in this country for a number of years, that the best form of butted longitudinal riveted joint for boilers is that in which the inside strap is wider than the outside, and has one or more rows of rivets which pass through the shell and the inside strap beyond each edge of the outside strap. The pitch of the first row of outer rivets is double that of the rows that pass through both straps, and if there are other outer rows they may or may not have a still greater pitch.

2 In England, where until comparatively recently boiler construction has been superior to ours, this form of joint appears to receive no recognition. It was first devised, as far as I know, by Dr. E. D. Leavitt, Past-President of the Society, and Edward Kendall, both of Cambridge, Mass., and was first used by Mr. Leavitt in some locomotive type boilers designed by him for the Calumet & Hecla Mining Company. I have a blueprint of this boiler dated 1879. It is, of course, hazardous to state that this joint was never used before and it is quite possible that it was used in England, discarded and forgotten as poor construction, as I believe it is. It was first used on an American locomotive by the Baldwin Locomotive Works in a consolidation locomotive built by them for the Calumet & Hecla Mining Company, the drawing of this joint having been made by me when I was in Mr. Leavitt's employ.

3 While every boilermaker has for years been familiar with butt joints, this form made slow progress towards adoption in this country. One form of joint used to avoid the butt joint and get something as good was a lap joint with an inside strap bent at the edge of the lap

To be presented at a meeting of the American Society of Mechanical Engineers. All papers are subject to revision.

and riveted on each side of it. This was used on locomotives exclusively, and was of little or no value as it was simply a somewhat elastic bent tie connecting the two parts of the shell plate. Finally, and fortunately, this joint gave way to the butt joint first described.

4 I believe there has been no case of an explosion of a butt-joint boiler; at least one due to rupture of the joint. Recently, however, a boiler at Woonsocket, R. I., narrowly escaped explosion, a longitudinal rupture of the plate on one side of the joint, and within its limits, being discovered while the boiler was subjected to steam pressure. The steam pressure was rapidly reduced and no explosion occurred. An account of this is given in Power, January 26, 1909, and the joint itself is in possession of the boiler-inspection department of the Massachusetts district police at the state house in Boston.

5 It has been growing upon me for some years that a one-sided boiler joint, such as that first described, is poor construction, and may sooner or later cause a crack in the plate. The Woonsocket phenomenon has tended to confirm this opinion. It is evident that unless the outside rivets fill the holes they do very little good, and when they do fill them they form an overhung connection and to some extent possess in themselves the now recognized defect of the lap joint. Moreover the extended inside plate forms a bent connection between the different rivets at different distances from the center line of the joint.

6 In many cases designers have placed the outside rivets at a considerable distance from the edge of the outside strap and this is constantly overdone. It is obvious, on careful thought, that the outside rivets should be as near the edge of the outside strap as practicable, thereby diminishing the bent-tie effect. In order to diminish this effect still further, and also to render the overhung rivets more effective, the inside strap should be thicker than usual, and this feature can hardly be overdone. The inside strap should be at least as thick as the shell plate, and great care should be taken to have the holes match and the rivets fill the holes.

7 When a joint of this kind is tested to destruction in a testing machine, it will be found to fail somewhat in detail, the inside strap bending slightly and the outside rivets being the last to rupture after yielding a little. In a boiler the joint would be weaker than a flat specimen on account of the bent-tie feature. This could be prevented if it were practicable to caulk the inside strap as it would thereby be compelled to maintain the circular form. The theoretical efficiency of this joint is greater than of any other kind, but in practice

I believe the efficiency is not realized and the defects that I have described render the joint, in my opinion, undesirable.

8 In order to avoid the defects of the one-sided butt joint, I have adopted and intend to use hereafter, a joint with both straps of the same width, as illustrated in Fig. 1. This has the merit of having all rivets in double shear and the strains all taken care of in the best manner. The efficiency of this joint can hardly be above 84 or 85 per cent while that of the one-sided joint can be theoretically 91 or 92 per cent; but the certainty that the efficiency of the former is realized in practice is ample compensation for the use of slightly thicker plates. The pitch of the outer rows of rivets is rather great, compelling the use of a thick outside strap in order to stand caulking and remain steam-tight. I use an equally thick inside strap in order to diminish the bent-tie effect. This effect is small, however, as the

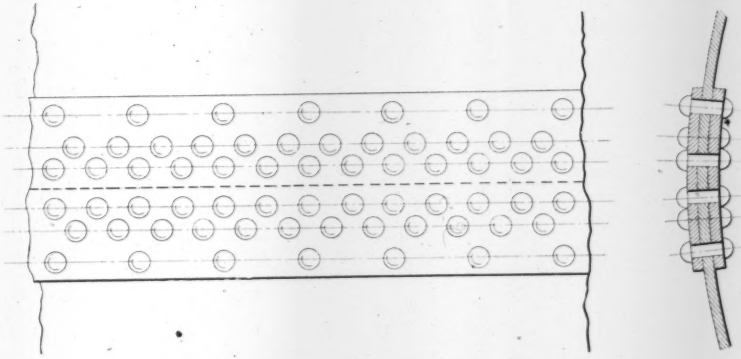


FIG. 1. RECOMMENDED FORM OF LONGITUDINAL JOINT

rivets are all near the center of the joint. It can be eliminated by caulking the inside strap, which is practicable with this joint, and is done in the best marine practice. This assumes that the caulking is effective and remains so.

9 While upon this subject, it is well to call attention to the perfection with which the longitudinal joints of boiler-plate cylinders can be welded, as has been demonstrated for many years with corrugated furnaces and more recently with soda digesters. While the joints of corrugated furnaces are in compression those of digesters are in tension, and their proved safety should be sufficient to overcome any timidity concerning the perfection and safety of welded joints. Circumferential are not so easily welded as longitudinal joints, and it is of course of little importance in boilers that they should be welded.

AN EXPERIENCE WITH LEAKY VERTICAL FIRE-TUBE BOILERS

By F. W. Dean, Boston, Mass.
Member of the Society

In 1905 I made a design for a large vertical fire-tube boiler, two of which were built, to be placed on a brick fire box provided with a chain grate. In accordance with a great number of precedents the water leg was short, being in fact 2 ft. deep below the underside of the crown sheet. Unusual provision was made for easy circulation by wide spaces between tubes at every 45 deg. of the circumference instead of the customary 90 deg. or as in some cases at 180 deg. The distance from the top of the grate to the underside of the crown sheet was 7 ft. The following are the general dimensions of the boilers as they now are:

Inside diameter of smallest course of shell	120⅞ in.
Inside diameter of largest course of shell	122 11/16 in.
Inside diameter of water leg	112 in.
Height of water leg	7 ft. 2¾ in.
Height of brick furnace	5 ft. 8 in.
Distance from grate to tube plate	12 ft. 2¾ in.
Outside diameter of tubes	2½ in.
Length of tubes	20 ft. 0 in.
Number of tubes	488
Pressure for which the boiler was designed	165 lb.
Kind of grate	B. & W. chain
Size of grate	8 ft. 6 in. by 9 ft. 0 in.
Grate area	76.5 sq. ft.
Water heating surface, say	4900 sq. ft.
Superheating surface	1181 sq. ft.
Total heating surface	6081 sq. ft.

2 The boilers were designed for S. D. Warren & Company and were used in their paper mill at Cumberland Mills, Me. They were built by the Portland Company of Portland, Me. Each boiler was

To be presented at a meeting of The American Society of Mechanical Engineers. All papers are subject to revision.

rated at 500 h.p., or substantially 1 h.p. for every 10 sq. ft. of water-heating surface, and was expected to work at 1000 h.p. a good portion of the time. Artificial induced draft was used and it was possible to obtain a draft of 2½ in. of water in the smoke box.

3 At the back end of the chain grate, instead of a water back or a brick back, a vertical or slightly inclined common grate was used, against which the unconsumed coke would accumulate, and under which the ashes would pass and fall upon the ashpit floor. Difficulty was found in making the coke accumulate uniformly and the ends of this grate were frequently bare.

4 The boilers were started gently and then operated at high capacity. After about two weeks a number of the tubes began to leak at the lower ends. They were expanded, but shortly began to leak again, and this process was repeated until the tubes were so injured that they could not be further expanded. They were then removed and new ends were welded on, but after a comparatively short time they leaked again. The leaks were more on the back half of the boilers than on the front. In winter when a nearby door in the building was open and cold air blew on the vertical grate, when the ends of the grate were bare, the leakage would increase. After learning how to keep the vertical grate covered, and keeping the door closed, the general trouble continued.

5 Knowing the sensitiveness to dirt on the crown sheet of vertical fire-tube boilers, as the design permitted access to the interior, these crown sheets were examined and found to be clean. Thinking that possibly some invisible oil had entered the boilers in some way, one of the boilers was boiled out with caustic soda, but with no effect.

6 The opinions of several boiler experts were obtained, but they differed and were unsatisfactory. One thought that the workmanship was poor, another that the design was the worst he had ever seen. Another thought that the tube plates were too limber and even recommended riveting crown bars to them to stiffen them.

7 Spring Hill coal from Nova Scotia was used at first, followed by New River coal from West Virginia. With the Spring Hill coal the lower ends of the tubes quickly became incrusted with clinker, and were finally closed by it and a little later the clinker would hang in stalactites from the tube ends. Not all of the ends would be closed, but this was the case with a large proportion of them. With New River coal there was less trouble. Spring Hill coal was satisfactory under horizontal boilers and never plastered over the tubes; in the vertical boilers, however, the incrustation was so hard

that it had to be removed with chisels. This incrustation was of course moulten earthy matter injected by the draft against the tubes and tube plate and there congealed by the comparatively low temperature of the metal. In the horizontal boilers it falls to the bottom of the setting before it arrives at the tubes. In water-tube boilers it can be seen adhering to the lower tubes.

8 The existence of this incrustation probably furnishes the explanation of the tube leakage. As a large proportion of the tubes became stopped up the others had to pass all the hot gases, the water about their ends was probably driven away and they became very much overheated, causing them to over-expand, to become upset, and at some later time, when they became cooler, to be loose in the holes.

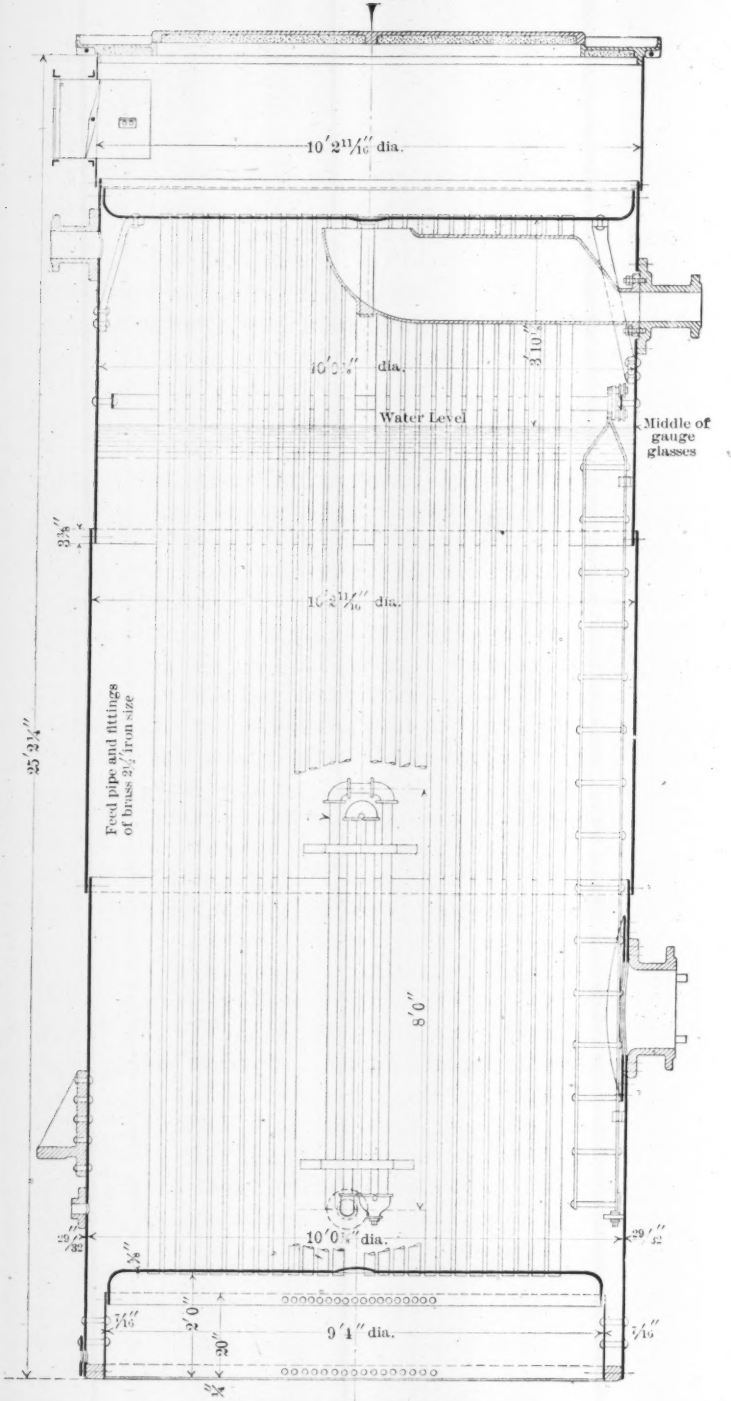
9 As a last resort, when it seemed as if the boilers must be consigned to the scrap heap, someone suggested that to lengthen the fire-box and raise the boilers by the amount of the extension might cure the trouble. One boiler was thus altered, started August 31, 1908 and run at the estimated rate of 1100 h.p. 24 hr. per day for some three months, without the slightest leakage, although the tubes were very thin from over-expansion. The other boiler was then altered, and started February 25, 1909. When the first boiler was worked at the estimated rate of 1100 h.p. it consumed 84,000 lb. of New River coal in 24 hr., burning it at the rate of 46 lb. per sq. ft. of grate per hr. Neither boiler has leaked up to the time of presenting this paper.

10 The distance from the grate to the tube plate is now 12 ft. $2\frac{3}{4}$ in. There is some incrustation, but it is light, brittle and easily crushed, and can be blown off by a rotating multiple tube-blower in the smoke box. The tubes are conveniently and quickly blown in this way every three or four hours.

11 The boiler plant at this mill consists of Babcock & Wilcox boilers, 90-in. horizontal return tubular boilers, and the two vertical boilers described. The latter were intended to reduce the space occupied, both on the floor and above. The rear drum of the chain grate is exposed and the clinker is dropped at the back end, where it is easily removed without inconvenience to the fireman. Above is room for the smoke flues and economizer, which with other types of boiler would have been placed, in this case, with difficulty.

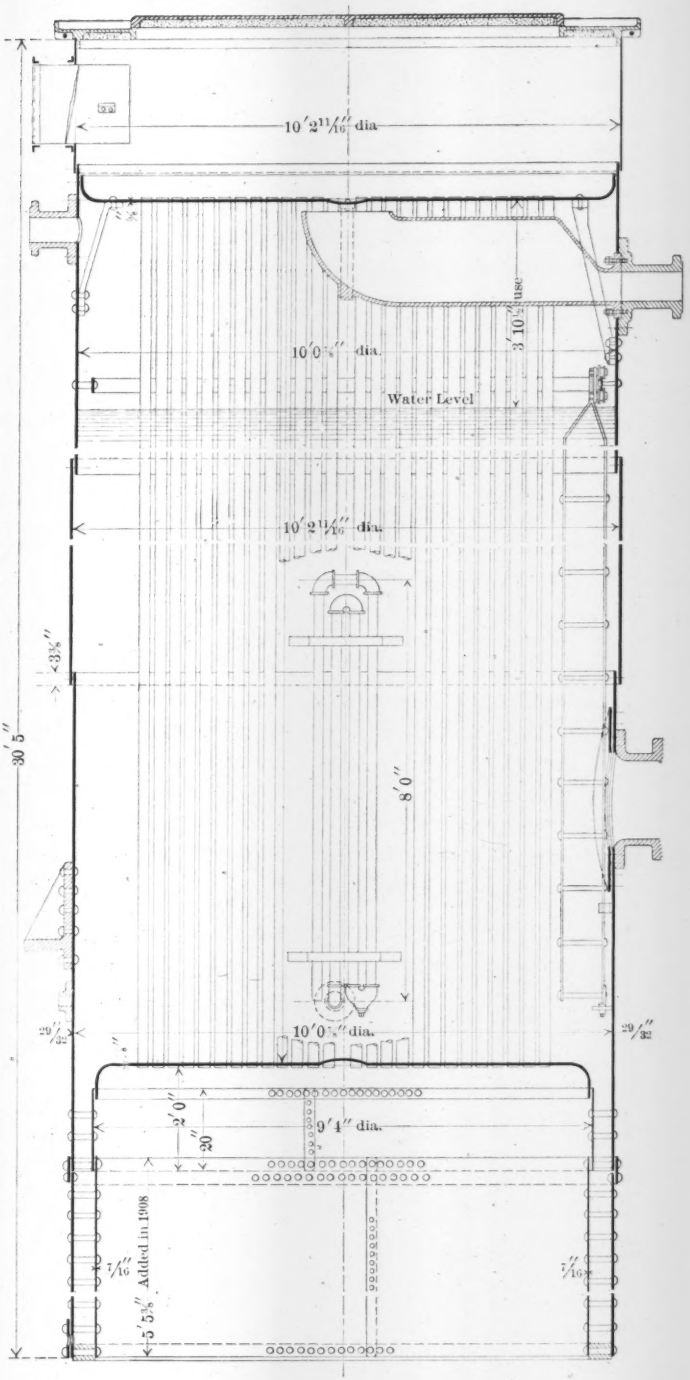
12 After these boilers had been operated long enough to show that they were reliable and a good investment, it was decided to test one of them, with the results given in the tables.

13 While the evaporation is good it is not satisfactory. The function of a boiler is to absorb the heat generated in a furnace. The



BEFORE ALTERATION

FIG. 1 BOILER BEFORE ALTERATION



AFTER ALTERATION

Fig. 2 Boiler After Alteration

furnace efficiency may be poor and the boiler efficiency good, and that was the case during these trials. The best furnace result occurs when the carbon is burned to CO_2 with as little surplus air as practicable. In these trials the CO_2 was low and some CO was nearly always found. It was impossible to get any better combustion for reasons which I do not know. Experiments will probably be made to ascertain this and overcome the trouble. It might disappear with another kind of stoker.

14 That the boiler efficiency was good is evident from the low temperature of the escaping gases, when developing over 1000 h.p., which is at the rate of less than 5 sq. ft. of water surface per horsepower. It will be noticed that the evaporation was best on combustible when the boiler was operated at double its rated horsepower. It was found impossible to keep the horsepower down to 500. This could only be done by reducing the grate area.

15 An interesting result of the tests is that the superheat was the same at all rates of power.

16 Returning again to the matter of clinker on tubes, it occurs on locomotives which burn anthracite coal, and I understand on locomotives of the Boston & Maine Railroad that burn coke. In the latter case coke-burning locomotives cannot be used on long runs, but whether a better quality of coke would be more successful I do not know. Professor Denton has informed me that clinker accumulated on the boiler tubes of a Transatlantic steamship on which he was a passenger to such an extent that men were sent into the combustion chambers to remove it. He also referred to a Manning boiler on which this trouble occurred.

TABLE 1 TESTS OF BOILERS

Time	Draft	Temperature	CO_2	O	CO	N
		April 29, 1909				
8.35– 9.00	0.75	575	7.6	11.2	0.6	80.6
9.05– 9.30	full	575	10.0	9.0	0.3	80.7
9.35–10.00	full	575	7.2	12.2	0.1	80.5
10.05–10.30	full	575	7.0	12.8	0.3	79.9*
10.35–11.00	full	580	7.8	11.2	0.1	80.9
11.05–11.30	full	600	7.0	12.8	0.2	80.0
11.35–12.00	full	620	7.8	11.6	0.1	80.5
12.05–12.30	full	620	8.2	10.7	0.2	80.9
12.35– 1.00	full	610	8.2	11.5	0.5	79.8
1.10– 1.30	full	585	7.7	12.3	0.1	79.9*
1.40–2.10	full	600	8.2	12.3	0.2	79.3
2.20–2.50	full	625	7.4	12.2	0.1	80.3*
3.00–3.25	full	585	7.0	13.3	0.0	79.7
3.35–4.00	full	600	4.8	14.8	0.0	80.4†
4.05–4.30	full	610	7.8	12.0	0.3	79.9
4.35–5.05	full	615	8.3	10.9	0.2	80.6
5.10–5.25	full	640	8.8	10.6	0.4	80.2
5.30–5.50	full	620	8.4			
		April 30, 1909				
8.05– 8.30	0.5	575	8.3	11.2	0.3	80.2
8.37– 9.05	0.5	540	8.3	11.1	0.1	80.5
9.15– 9.37	0.5		13.5	5.3	0.8	80.4‡
9.45–10.10	0.4	500	10.7	7.8	0.9	80.6‡
10.20–10.45	0.2	500	10.0	8.7	0.4	80.9‡
11.05–11.30	0.2	510	11.0	7.4	0.6	81.0
11.35–12.00	0.2	520	9.6	8.8	0.8	80.8
12.05–12 30	0.2	525	7.9	11.8	0.2	80.1§
12.35– 1.10	0.2	500	6.7	12.7	0.0	80.6
1.15– 1.45	0.2	525	7.9	12.2	0.2	79.7
1.50– 2.25	0.2	515	7.1	12.5	0.1	80.3
2.30– 3.00	0.2	485	7.0	11.6	0.1	81.3
3.05– 3.35	0.2	520	6.3	13.9	0.0	79.8*
3.40– 4.00	0.2	560	7.4			
		May 1, 1909				
8.00– 9.00		520	7.3	13.3	0.0	79.4
9.15–10.00	0.8	525	7.2	12.8	0.0	80.0
10.00–10.55	0.8		5.0	14.5	0.0	80.5
11.05 11.40	0.9	530	7.7	11.6	0.2	80.5
12.45– 1.30	0.7	530	9.0			
1.30– 2.30	0.7	560	8.6	10.4	0.3	80.7
2.40– 3.30	0.7	555	6.0	13.2	0.0	80.8

*Cleaned fire.
†Thin on backside.
‡Fire thick and banked.
§Fire thinner.

TABLE 2 RESULTS OF BOILER TRIALS

RUNNING START-AND-STOP METHOD OF TRIAL, VERTICAL FIRE-TUBE BOILER, NEW RIVER SLACK FUEL

1	Date of trial	Apr. 29	Apr. 30	May 1
2	Duration of trial, hours	7	8	8
3	Number of boilers in use	one	one	one
	DIMENSIONS AND PROPORTIONS			
4	Grate surface 8 ft.6 in. by 9 ft. 0 in., square feet	76.5	76.5	76.5
5	Water-heating surface, square feet	4900	4900	4900
6	Superheating surface, square feet	1181	1181	1181
7	Total heating surface, square feet	6081	6081	6081
8	Ratio total heating surface to grate surface	79.5	79.5	79.5
	AVERAGE PRESSURES			
9	Steam pressure, by gage, per square inch, pounds	129.8	124.3	126.8
10	Atmospheric pressure per sq. in., pounds	14.7	14.7	14.7
11	Absolute steam pressure per square inch, pounds	144.5	139.0	141.5
12	Force of draft in column of water between damper and boiler, inches	1.47	0.28	0.63
	AVERAGE TEMPERATURES			
13	External air	38	35	39
14	Feed-water before entering	50.6	63.6	58.2
15	Escaping gases after leaving	609.1	517.3	558.6
16	Steam	372	369	371
	FUEL			
17	Moist coal consumed, pounds	24,192	17,030	21,782
18	Moisture in coal, per cent	3.06	1.45	4.55
19	Dry coal consumed, pounds	23,452	16,783	20,791
20	Wood consumed, pounds	0	0	0
21	Total dry refuse, pounds	2361	1310	1650
22	Total dry refuse, per cent	10.02	7.8	7.94
23	Total combustible, pounds	21,091	15,473	19,141
24	Dry coal consumed per hour, pounds	3013	1934	2393
	QUALITY OF STEAM			
25	Moisture, per cent	0.00	0.00	0.00
26	Degrees superheated	17	17	17
	BRITISH THERMAL UNITS			
27	Number of heat units in a pound of dry coal, by oxygen calorimeter	14,759	14,759	14,759
28	Number of heat units in a pound of combustible, by oxygen calorimeter	15,760	15,760	15,760
29	Specific heat of superheated steam at constant pressure	0.61	0.61	0.61
30	Heat units absorbed per pound of steam generated	1182	1174	1167
31	Heat units imparted to boiler per pound of dry coal	9901	10,075	9893
32	Heat units imparted to boiler per pound of combustible	11,009	10,929	10,746
	EFFICIENCIES			
33	Efficiency based on dry coal, per cent	67.1	68.3	67.0
34	Efficiency based on combustible, per cent	70.0	69.3	68.2
	FACTORS OF EVAPORATION			
35	Factor of evaporation	1.224	1.215	1.209

TABLE 2 RESULTS OF BOILER TRIALS.—Continued

	Date of trial	Apr. 29	Apr. 30	May 1
	WATER			
36	Total water pumped into boiler, pounds	196,441	144,025	178,250
37	Water actually evaporated, corrected for quality of steam	198,185	145,321	179,854
38	Equivalent water from and at 212 deg. fahr., pounds	242,578	176,633	217,444
39	Equivalent water from and at 212 deg. fahr., per hour, pounds	34,654	22,079	27,193
	EVAPORATIVE PERFORMANCE			
40	Water actually evaporated per pound of dry coal, pounds	8.45	8.66	8.65
41	Equivalent per pound of dry coal from and at 212 deg. fahr., excluding economizer, pounds	10.34	10.52	10.46
42	Equivalent per pound of combustible from and at 212 deg. fahr., excluding economizer, pounds	11.50	11.42	11.36
	COMMERCIAL HORSEPOWER			
43	On basis of 34½ lb. of water from and at 212 deg. fahr., per hour, by boiler h. p.	1005	640	788
44	Heating surface of water surface per horsepower, square feet	4.87	7.66	6.22
45	Horsepower per square foot of grate surface, h.p.	13.14	8.36	10.30
46	Rated horse power	500	500	500
47	Percentage developed above rating	101	28	58
	RATE OF COMBUSTION			
48	Dry coal actually burned per square foot of grate surface per hour, pounds	39.1	25.3	31.3
49	Dry coal burned per square foot of water-heating surface, per hour, pounds	0.61	0.39	0.49
	RATE OF EVAPORATION			
50	Water evaporated per square foot of heating surface per hour from and at 212 deg. fahr., pounds	7.05	4.50	5.55

DISCUSSION AT WASHINGTON MEETING

TESTS ON COMPRESSED-AIR PUMPING SYSTEMS OF OIL WELLS

By Edmund M. Ivens, Published in The Journal for May

ABSTRACT OF PAPER

This paper comprises a brief general description of the compressed-air plants of the various concerns operating on the Evangeline, La., oil-fields, with an explanation of the terms as applied to pneumatic pumping; and deals especially with the systems of pumping formerly used in the oil wells as compared with an improved system which has replaced the earlier ones. A series of tes's is given showing the cost of operation, efficiency, etc., of the new and old systems.

DISCUSSION

F. A. Halsey. The air-lift pump is one of those things of which our knowledge is almost exclusively experimental. Its analysis presents such serious difficulties that rational equations for the performance of the apparatus have not been derived by anyone to my knowledge. Under these circumstances, we are reduced to experiment for the determination of the fundamental laws of the performance of the apparatus, and these experiments should cover a wide range in the conditions which lead to variation in the performance of apparatus, namely, depth of submergence and lift.

2 The most complete experiments now on record were presented in a paper before the British Institution of Civil Engineers in 1906,* these experiments being of sufficiently wide scope to supply a satisfactory guide for the design of these pumps under a considerable range of conditions.

3 One curious feature attends the behavior of the air-lift pump and the Taylor hydraulic air compressor, which are essentially the same

*Abstracted in the American Machinist, August 16, 1906.

apparatus, reversed in action. In each case we have a pair of vertical pipes communicating at the bottom, one filled with water and the other with a mixture of air and water—a sort of suds. If the pipes are of indefinite length the columns will take levels corresponding with their respective gravities, but if the suds pipe is cut off below this level it will overflow, the suds will rise, and we have an air-lift pump: while on the contrary, if the water pipe is cut off below this level, it will overflow, the column of water will rise, and we have a Taylor hydraulic air compressor. The point to which I refer is that while the first of these constructions has a low, the second has a high efficiency. The highest figure given in this paper for the efficiency of the pump is about 28 per cent, and while 40 per cent has been reached in exceptional cases, the average is probably not more than 20 per cent. On the other hand, the efficiency of the hydraulic air compressor is in the vicinity of 75 or 80 per cent.

DR. SANFORD A. MOSS. The method used by the author for computation of volumetric efficiency is subject to serious inaccuracies, as he points out. For the purpose of the tests in question, where relative rather than absolute volumetric efficiencies are desired, the method is quite proper. The volumetric efficiencies given must be understood to be relative and not absolute, however, as the errors may be quite serious. I have used the method which the author states he would have preferred for ascertaining volumetric efficiency, Par. 23, and found it very good. Everything operated as would be expected and a reputable value of volumetric efficiency was obtained. In one case, the method as given in Par. 23 was checked by use of calibrated orifices, and also by use of a single tank with rise of pressure, the rate of increase of pressure when the pressure reached the rated value giving the desired volumetric efficiency. All three methods checked very closely. The volumetric efficiency in this case was 58 per cent, showing the serious losses which can occur due to the inaccuracies mentioned.

J. G. CALLAN.[1] Par. 21 to Par. 23, with diagram (Fig. 7), refer to the method of determining the efficiency of the air compressor, and Mr. Ivens states in Par. 23 the method which he would have preferred for determining this quantity.

2 The method of pumping up pressure in a large tank is open only to the objection that the large tank is rarely obtainable, particularly

[1] General Electric Co., Schenectady, N. Y.

when the pressures which it is proposed to use are high, and the volume large. A more available and almost equally exact method is afforded by the use of calibrated orifices of which the discharge coefficient has been duly determined. These orifices can be used in connection with well-known formulæ, which involve a knowledge of corrected pressure and temperature of air delivered to orifice, and of velocity and temperature of emergent jet, all factors which can be readily and accurately determined.

3 The losses of a compressor are so considerable and so complex that the assumption of volumetric efficiency from the indicator card may be in error by extremely large percentages and is quite as likely to be misleading as enlightening, unless results are strictly comparative rather than absolute. The value of the present tests would apparently be somewhat affected by the errors in this method of determining delivery, since certain elements of compressor loss would assume different percentage values with different discharge rates.

4 This brings up the desirability of some well-understood standardized method of testing compressors and other apparatus for delivering air. Commercial loss is certain to arise from the considerable variations in terminology and a definition of terms by an authoritative body such as this Society would be of marked advantage. For example, volumetric efficiency undoubtedly should mean the ratio between the air actually discharged (when restored to standard atmospheric conditions of temperature and pressure) to the air which would have been discharged had the compressor cylinder been completely filled on each stroke with air under standard atmospheric conditions, and had all the air displaced been completely discharged. The exact method of determining the approximation of real to theoretical discharge obviously should be only a secondary consideration in such a definition, but could properly be taken up as corollary.

5 The segregation and determination of losses in air compressors of different types form an interesting and useful line of investigation upon which little has been published. A considerable amount of work with which I am familiar indicates that these losses are usually materially greater than the customary assumptions, particularly in compressors which have been in service for some time. Various methods have been devised for independently estimating loss due to heating of intake, leakage of inlet, discharge valves and piston, clearance loss, throttling, and losses due to improper setting of mechanical valve gears, but usually these determinations will involve more labor than a direct measurement of air output by orifice and impact tube.

It is my belief, however, that the computation which neglects all of these losses except the clearance loss, particularly where the pressure is high and the compressor is somewhat worn, is almost sure to be very gravely in error.

THE AUTHOR. The discussions of the paper on oil-well pumping presented at the Washington meeting were centered on the method of ascertaining volumetric efficiency of air compressors. The object of the paper was rather to compare the relative efficiencies of various air-lift systems when being operated on extremely high pumping heads. However, as all the discussions were agreeable to the writer's views and methods, there is no room for argument.

SOME PROPERTIES OF STEAM

By Prof. R. C. H. Heck, Published in The Journal for May

ABSTRACT OF PAPER

Recent information as to the pressure-temperature relation for saturated steam, and the specific heat of water, is presented in this paper. The author summarizes the important work of Holborn and Henning and gives their table in English measures, showing the pressure p for each deg. fahr. from 32 deg. to 402 deg.; also the rate of change dp/dt derived by him, which is sufficiently exact for effective use in calculating specific volume.

On the subject of the specific heat of water, the author graphically compares the results of Regnault, Barnes and Dieterici, together with the values used by Peabody; and expresses an opinion in favor of Dieterici. He also discusses the relative magnitude of the "mean" heat unit and of that at 15 deg. cent., recommending the use of a conversion factor of the value 0.0011, or 1 in 900, as decidedly preferable to the change in the numerical value of the mechanical equivalent of heat which must accompany the adoption of the mean unit.

DISCUSSION

Dr. Sanford A. Moss. In Regnault's original paper on pressure and temperature of saturated steam was given an empirical formula, first suggested by Roche, but reconstructed by Regnault and called "Formula K." This represented Regnault's results more closely than any other single formula and has also been shown to represent other experimental results, particularly those for very high pressures and temperatures. This formula was discussed by Ramsey and Young in the Philosophical Transactions, Vol. 183, 1892, page 111, and also in London Engineering, Vol. 83, January 4, 1907. I have given some discussion of this matter in the Physical Review, Vol. 25, No. 6, December 1907. It would be interesting if Professor Heck would give a comparison of the values of his table with those computed by this formula. If it can be demonstrated, as is the conclusion in the papers above mentioned, that this formula represents all of the experi-

mental results very closely, it is highly desirable that it be used. Thermodynamic computations can be carried on very readily, if we have a single formula for the entire range.

PROF. G. A. GOODENOUGH.[1] Since the experimental results of Holborn and Henning have been generally accepted, it seems highly desirable to have an analytical relation that will express these results with a sufficient degree of accuracy. For this purpose the formula of Bertrand,

$$\log p = k - n \log \frac{T}{T - a} \qquad [1]$$

seems to be quite suitable. In this formula k, n and a are constants and T denotes the absolute temperature.

2 The values of the constants can be so chosen that the formula will give fair results throughout the ordinary range of temperatures with one set of constants. A closer agreement, however, is obtained by dividing the temperature range into three parts. The values of the constants are:

For $t =$ 32 deg. – 90 deg., $k = 6.23167$, $a = 140.1$ $n = 50$
For $t =$ 91 deg. – 237 deg., $k = 6.30217$, $a = 141.43$ $n = 50$
For $t =$ 238 deg. – 400 deg., $k = 6.27756$, $a = 140.8$ $n = 50$

3 The derivative $\frac{dp}{dt}$ takes the simple form

$$\frac{dp}{dt} = \frac{pna}{T(T - a)} \qquad [2]$$

from which follows

$$T \frac{dp}{dT} = \frac{pna}{T - a} \qquad [3]$$

This relation is important since the product $T \frac{dp}{dT}$ appears in the Clapeyron-Clausius formula for steam volume. Table 1 shows a comparison of the values of p and $\frac{dp}{dt}$ calculated from Formulæ 1 and 2, respectively, with the values obtained by Professor Heck.

4 It will be seen that the maximum difference between the corresponding values of p is about 0.1 per cent. The maximum difference between the corresponding values of the derivative is greater.

[1]Associate Professor Mechanical Engineering, University of Illinois, Urbana, Ill.

COMPARISON OF VALUES OF p AND $\frac{dp}{dt}$

t	p BECK'S VALUE	p BERTRAND'S FORMULA	dp/dt HECK	dp/dt BERTRAND'S FORMULA
32	0.0886	0.0885	0.003575	0.003588
50	0.1780	0.1781	0.00663	0.006625
75	0.4289	0.4288	0.01425	0.014245
100	0.9462	0.9455	0.02849	0.028575
125	1.9382	1.9387	0.05295	0.052921
150	3.7141	3.7144	0.0921	0.092041
175	6.714	6.711	0.1519	0.15165
200	11.527	11.523	0.2384	0.23843
225	18.913	18.921	0.3591	0.35985
250	29.820	29.834	0.5210	0.52039
275	45.40	45.382	0.7334	0.73248
300	66.98	66.94	1.0035	1.0027
325	96.11	96.07	1.339	1.3390
350	134.51	134.50	1.746	1.7489
375	184.07	184.18	2.231	2.2394
400	246.93	247.20	2.807	2.8167

Evidently this is due to the fact that the values of $\frac{dp}{dt}$ were obtained by Professor Heck (and also by Professor Peabody) by a method involving some approximation; and it is likely that the values calculated from Formula 2 are the more reliable.

5 A great advantage of Bertrand's formula lies in the ease with which it may be used in calculation. This is shown by the following scheme, which is copied from calculations recently made for the engineering experiment station of the University of Illinois:

$t=$	311	312	313	314
$T=$	770.58	771.58	772.58	773.58
$T-a=$	629.78	630.78	631.78	632.78
$\log T=$	2.8868177	2.8873810	2.8879435	2.8885052
$\log T-a=$	2.7991889	2.7998779	2.8005659	2.8012527
$\log \frac{T}{T-a}=$	0.0876288	0.0875031	0.0873776	0.0872525
$50 \log \frac{T}{T-a}=$	4.381440	4.375155	4.368880	4.362625
$k=$	6.27756	.....		
$\log p = k - 50 \log \frac{T}{T-a}=$	1.896120	1.902405	1.908680	1.914935
$p=$	78.726	79.874	81.036	82.212
$\log na=$	3.8475727	.....		
$\log pna=$	5.7436927	5.7499777	5.7562527	5.7625077
$\log \frac{pna}{T-a} = \log T \frac{dp}{dt}=$	2.9445038	2.9500998	2.9556768	2.9612550

6 In conclusion, it may be stated that Bertrand's formula seems to have a wide range of applicability, and with proper choice of constants can probably be used equally well for nearly all saturated vapors.

THE AUTHOR. The preparation of this paper was an early step in a special study of the properties of steam upon which the writer has been engaged for some months; the object of this investigation has been to formulate more precisely our knowledge of the subject up to the limit of accurate experiment, at about 400 deg. fahr., and to extend the relations into the higher ranges, even up to the critical temperature. It has been found that Thiesen's formula, by modification of the two coefficients or constants, can be made to fit the Holborn-Henning table exactly from 100 deg. to 200 deg. cent., and that this modified equation holds good up to about 450 deg. fahr. Above that point the curve begins to rise more rapidly, and even crosses the original Thiesen curve. Below 212 deg., the relation can be very exactly extended by means of a small adjustment from the Thiesen values.

2 The formula presented by Professor Goodenough fits the data very well; but for precise calculation it has the disadvantage that at each point of change in constants there will be a break in the curve of the derivative $\frac{dp}{dt}$. The Thiesen formula has a forbiddingly complex expression for its derivative, and would be much less convenient for regular use, if the calculation of $\frac{dp}{dt}$ were an operation to be undertaken frequently.

3 The writer has tried formula K, which is recommended by Dr. Moss. In the very high range it runs low in p, dropping beneath the modified Thiesen formula, which itself is not high enough for the more reliable data.

4 The values of $\frac{dp}{dt}$ in Table 1, found simply by the method of differences, are not precise enough for close work with Clapeyron's equation, the irregularities resulting from the use of them running as high as nearly one-fifth of one per cent. It is the hope of the writer to present to the Society in the near future the results of the special study of the properties of steam mentioned above.

A NEW DEPARTURE IN FLEXIBLE STAYBOLTS

By H. V. Wille, Published in The Journal for January

ABSTRACT OF PAPER

While the ordinary formulæ for flexure do not strictly apply, they have been employed to indicate the magnitude of the stresses in a staybolt. This paper shows that a 1-in. bolt may be stressed to 48,000 lb. per sq. in. and proposes the employment of tempered spring steel in the manufacture of staybolts capable of sustaining this high unit stress. The stem of the bolt is made of tempered spring steel and the ends of soft steel so as to permit riveting over in the boiler. Such a bolt possesses a double advantage in that it is manufactured of material capable of resisting a high unit fiber stress and on account of its small diameter is stressed in flexure to a less extent than the usual type of bolt.

DISCUSSION

William Elmer. The decrease in the diameter of a staybolt, from 15/16 in. or 1 in., which I believe is the present practice, to a small diameter, as 7/16 in., even if the tensile strength of the material is increased, brings to mind at once the possibility of twisting off these small bolts in their mechanical application to the boiler. The writer hopes Mr. Wille will say something about this.

W. E. Hall. Any one who has had the care of the locomotive type of boiler appreciates that staybolt maintenance is a source of intense anxiety, and that the fact that more disastrous results are not forthcoming reflects great credit on the vigilance of the motive power departments of our railroads. This result, however, is accomplished only at high maintenance cost, which, fortunately, has always been of secondary consideration.

2 Flexibility and length, of which Mr. Wille speaks, no doubt have considerable influence on the breakage of these bolts. It would be

interesting to have details showing the construction of the bolts, and just how they were held, in his vibratory tests.

3 It should be noted, however, that his construction calls for a studbolt of larger diameter than the ordinary staybolt, and in addition this studbolt must project into the leg of the boiler to give sufficient length of thread-contact of the staybolt proper in the studbolt; in other words, he increases the diameter (the studbolt), introduces two threaded surfaces to the strain of flexure, and shortens the staybolt an amount equal to the projection of the studbolt into the leg of the fire-box. Is this not contrary to his own deductions? Assuming that this construction would decrease, but not eliminate, broken staybolts, would this construction facilitate their detection, difficult under the best conditions, or make it more difficult? The reduced length might be relieved by making the fit of the thread of the bolt in the studbolt looser than that of the studbolt in the sheet, thereby always throwing the point of flexure upon the studbolt at the side of the outer sheet. But this is a risky procedure hardly deserving of consideration in boiler practice.

4 The breakage of staybolts is confined almost exclusively to the upper rows of bolts of the legs of the fire-box. The fracture usually starts from the top, sometimes from the side, not infrequently around the circumference and occasionally from the bottom. The fracture is almost always close to the outer sheet, but a break close to the inside sheet is not unknown. The fracture is always in detail, barring shamefully defective material or workmanship, or at least up to the point where the remaining area in contact is not sufficient to withstand the strain to which that reduced area of the bolt is subjected. More or less irregularity of the line of fracture is to be expected. Conditions are not always the same for every bolt: all bolts do not fit the sheets alike, there is more or less variation in the upsetting, and the buckling and warping of the inner sheet is not the same for each bolt. These, together with other minor conditions, representing reasonable refinement in practice, preclude uniformity of the fracture.

5 But the important points are, that these bolts always break in *detail* and always at the *root of the thread.* Have we any reason to expect that it would be otherwise? For example, if we wish to break a piece of metal we first grip it in a vise, notch it close to the jaws of the vise and bend it back and forth. We do the same with a staybolt when we cut the thread with a sharp die (and in this respect the U. S. Standard is inferior to the Whitworth), hold it firmly in the outer sheet and subject it to the bending due to the expansion, con-

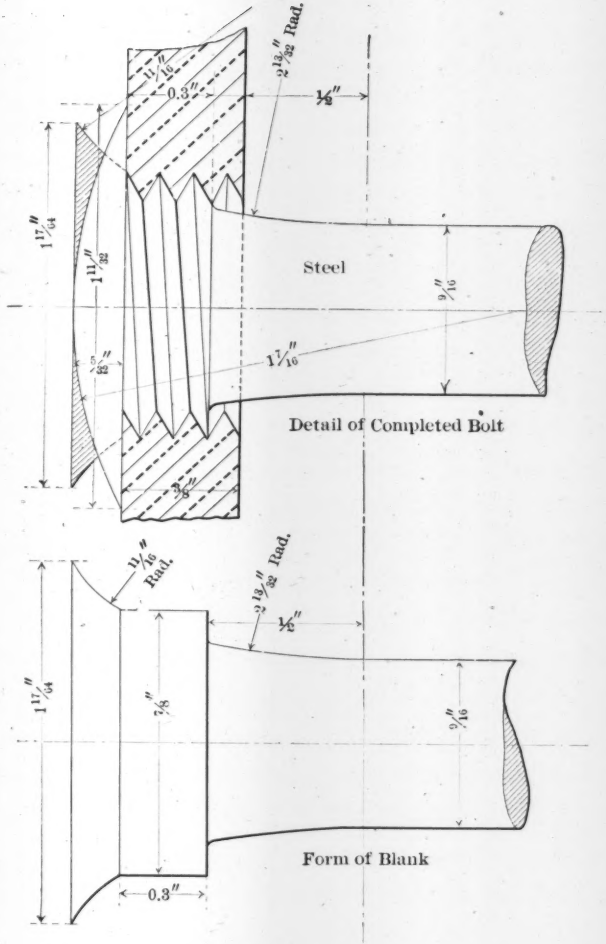


FIG. 1 BLANK AND COMPLETED ENDS OF FLEXIBLE STAYBOLT

traction and warping of the inner sheet. Cutting the thread produces a constructive defect. This feature is necessary as the bolts are now used and its correction is beyond the scope of mathametics.

6 Fig. 1 and Fig. 2 show designs for bolts made in January 1886. The object was to make the bolt of iron or steel and by a gradual reduction from the ends towards the center to make the body of the bolt more flexible; and to make the length of the end such that, after making sufficient allowance for upsetting, the thread could not project beyond the face of the inside of the sheet, thus preventing the thread from being subjected to the strain of flexure. This feature is of the utmost importance. The flare on the end of the bolt was shown merely as a more ready means of upsetting the end, especially when the bolt is of steel. As the number of bolts breaking at the face of the inside sheet is so small as to be negligible, probably still smaller with a more flexible bolt, it would be necessary to control these con-

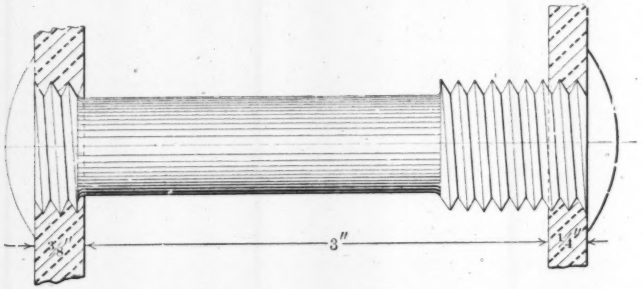


FIG. 2 FLEXIBLE STAYBOLT WITH END SHOWN IN FIG. 1

ditions only at the end in the outer sheet. As this is usually 1/16 in. thicker than the inside sheet, the length of this special end could be readily controlled to prevent the thread projecting beyond the inside face and thereby totally eliminating all bending strain at the root of the thread.

7 To accommodate the difference in widths in the leg of the firebox the bolts could be made of varying lengths on a bolt machine and kept in stock. More or less variation in the length of the projected threaded area at the inside sheet is not important. By this method, if made by upsetting, it would not be necessary to turn the shank of the bolt. In all lengths, however, the end of the bolt for the outer sheet should be made such that there would never be more than enough for the upsetting and only an additional length of thread sufficient to prevent it from projecting beyond the inside face of the outer sheet.

8 This construction would permit of better circulation on account of less obstruction. It would increase the cost of boiler construction somewhat, but this, with the requirements fulfilled, would be insignificant in comparison with the elimination of the faulty feature and the reduction in maintenance cost.

ALFRED LOVELL. The durability of staybolts in high-pressure locomotive boilers is a prominent factor in the cost of locomotive maintenance and has an important bearing on the safety of the public. Any innovation intended to increase their durability or reliability is therefore worthy of the most careful demonstration and service trial. The staybolt described by Mr. Wille is of this character, and his paper clearly shows the desirability of providing a staybolt of high elastic limit and great flexibility.

2 This is accomplished by the use of metal having the requisite qualities in a high degree, and yet maintaining in the direction of the bolt's axis, the desirable features of continuity and rigidity, thus avoiding the liability of unequal tension of adjacent bolts. This is undeniably a departure in the right direction, and one that will receive prompt attention in railway mechanical engineering.

3 One other important feature to be considered, however, in adopting a new form or in selecting a new material for staybolts, is ability to resist corrosion under the conditions of use, a feature even more important with staybolts of the proposed high tensile strength and small diameter, than with staybolts of ordinary diameter. For example, the paper gives the actual breaking strength of a 1-in. iron bolt as 32,500 lb., and of a $\frac{7}{16}$-in. spring-steel stembolt as 32,000 lb. If it is assumed that each is reduced $\frac{1}{8}$ in. in diameter by corrosion, this will reduce the breaking-strength of the 1-in. bolt by 23.56 per cent, and of the $\frac{7}{16}$-in. bolt by 48.98 per cent. The breaking-strength of the iron bolt is then 24,843 lb. and that of the spring-steel stembolt is 16,327 lb. Another $\frac{1}{8}$-in. reduction in diameter would bring the strength of the iron bolt to 18,278 lb., and of the spring-steel stembolt to 5878 lb.

4 Formula 4 of Mr. Wille's paper shows that the flexural stress, the ordinary cause of failure, decreases directly as the diameter, yet it is evident that if the bolts are affected by corrosion and in equal amount, this will eventually reduce the tensile strength of the small bolt to a point below the proper factor of safety, while the larger bolt has still tensile strength to spare.

5 Since the new type of staybolt makes it possible to employ

various steels and alloys which cannot be used in the ordinary staybolt, it fortunately provides for a wide range of selection, and quite probably a steel-alloy or mixture may be provided that will resist corrosion equally well or better than the iron ordinarily used.

6 The impurities in the water used also very greatly affect corrosive action, and it is probable that with the new type of bolt it would be advantageous to examine carefully the water of the locality where it is to be used and to select a metal with reference to the character of the water. Information regarding the resistance of various steel alloys to corrosion, in water of ordinary purity, and experiments determining the metal that will give the least corrosion in water having various impurities, are highly desirable, since the new bolt makes possible the use of that metal which combines in the greatest degree flexibility, high elastic limit and resistance to corrosion.

7 A combination of these three qualities, in a staybolt of the type described, will be an innovation much to be desired in locomotive practice.

F. J. COLE. In reading this paper the following occurred to me:

a Have any of these staybolts been applied to locomotive boilers?

b What is their comparative cost?

c With 1-in. ends is there any danger of overstraining the $\frac{3}{8}$-in. diam. spring-steel center in screwing the bolt to place? It would seem that the torsional stress on the comparatively small central part in screwing the bolts to place when they fit tightly in the sheets would be excessive.

d In upsetting the soft ends, does the $\frac{3}{8}$-in. diam. center afford sufficient resistance to avoid injury to the threads from hammering? It is customary in upsetting the ends to use a hammer or heavy weight at the other end of the bolt to afford the necessary resistance and to prevent injury to the threads.

e In Par. 7 Mr. Wille speaks of 12,000 lb. fiber stress being good practice. I presume he has in mind the combined stress due to tension and bending. Current locomotive practice is represented fairly well by 5500 to 6000 lb. for tension alone.

THE AUTHOR. Mr. Hall has fully described the general characteristics of a staybolt broken in service. The able experiments of Boushinger and Wohler have shown that a detail fracture occurs in parts which have been stressed by flexure above the elastic limit. If the parts be threaded the stress may be localized at the base of the thread which will increase the possibility of failure of parts stressed at or near the elastic limit, but if the parts be not stressed above the "fatigue" elastic limit of the material, it will not fail irrespective of whether it be threaded or of plain section.

2 The bolt described is made of two kinds of material:

a The stem of high-carbon tempered steel.
b The two ends of soft steel.

This arrangement permits the use of a material having such a high elastic limit and provides an ample factor of safety and still allows the soft ends to be rivetted over to make a steam-tight joint. The bolt referred to by Mr. Hall does not fulfil these conditions, as if it were made of steel having a sufficiently high elastic limit it would be impossible properly to rivet the ends.

3 The ends of the composite bolts are not larger than a normal bolt, those in service being made 1 in. in diameter when used in new boilers and $\frac{15}{16}$ in. and $1\frac{1}{16}$ in. when used to replace $\frac{7}{8}$-in. and 1-in. bolts respectively in old boilers. The stems are not made a tight fit into the ends but are threaded so that they can be tightly screwed into the ends by hand thus affording some flexibility in the joint. It is not necessary however to thread the stems as they can be upset and the ends closed around them, making a ball joint, thus having all the advantages with none of the disadvantages of the usual type of flexible bolt.

4 The bolts have been in service for two years in a district notorious for the trouble experienced with corrosion and the bolts are still intact. Mr. Lovell suggests the possibility of providing special steels to resist corrosion. The high-carbon tempered steel being dense and hard is an admirable material to resist corrosion; furthermore as the stems are oil-tempered they have a coat of enamel which prevented the slightest amount of pitting even after two years' service.

5 There are a large number of these bolts in service in locomotive boilers and no difficulty has been experienced either from twisting of the stem in screwing into the boiler or from injury to threads in rivetting.

6 The cost of material entering into the construction of the spring

flexible bolt is very much less than that of the usual type of staybolt since the weight is much less and the materials are the relatively cheap commercial grades of steel instead of the high-priced irons usually employed in the manufacture of staybolts. The labor cost to manufacture is however somewhat higher.

MISCELLANEOUS DISCUSSION

AUTOMATIC FEEDERS FOR HANDLING MATERIAL IN BULK

By C. Kemble Baldwin, Published in The Journal for May

ABSTRACT OF PAPER

This paper is presented with the object of enabling an engineer to choose from eleven types of feeders in use to-day, the one best fitted to his use, line drawings being used so they may be readily compared. When feeding a conveyor, crusher or machine from a storage bin, it is advisable to use some type of automatic feeder. This should be geared to the machine it feeds so that they will start and stop simultaneously. The author favors the shaking feeder because of its simplicity and flexibility.

DISCUSSION

T. A. Bennett. An automatic feeder is absolutely necessary in some installations; in others it is demanded for economic reasons. For example, run-of-mine coal, on account of constriction in the chute, requires properly a 36-in. belt, although it can be handled on a 30-in. belt. With an automatic feeder it is possible to use a 24-in. conveyor provided the capacity will permit. In handling damp sand, a large chute opening is necessary and this usually requires at least a 16-in. conveyor belt. With a feeder, however, this width can easily be reduced to 12 in. A 12-in. conveyor has capacity to take care of nearly every problem in handling damp sand.

2 The feeder is also economical in filling in the blank spaces on the belt. The loading is usually intermittent, the belt being either over-loaded or under-loaded intermittently; the feeder can be regulated to give a uniform maximum loading, greatly increasing the capacity. Intermittent loading also increases the wear on the belt. As the only wear worth considering is that done by the material

coming in contact with the surface of the belt in the delivery of material to it, the larger the load the less is the proportionate wear on the belt.

3 A type of feeder has been developed similar to that in Fig. 8, but doubled; that is, a hopper and either one or two swinging plates at each end and pushing to an outlet at the center part of the skirt boards. This type is now working very satisfactorily in two big plants, the Hudson Company's power house at Jersey City, N. J., and the Illinois Steel Company at Joliet, Ill. The chief advantage over any other is the saving of headroom. Where there is sufficient headroom, the shaker feeder is correct practice and is in general use.

THE AUTHOR. Mr. Bennett's discussion emphasizes three important points with reference to the use of automatic feeders in connection with belt conveyors:

a The installation of the feeder frequently permits the use of narrower belts.

b Delivery of an even and continuous stream of material enables the conveyor to operate at its maximum capacity.

c By loading the conveyor to its full capacity, a smaller proportion of the load comes in contact with the belt, thereby reducing the wear per ton carried on the belt at the loading point.

2 The type of feeder mentioned by Mr. Bennett as similar to that illustrated in Fig. 8 is a variation of that type, used where material is taken from two hoppers; instead of two swinging plates placed side by side, there is a single plate under each hopper. These two plates are connected by rods, so that when one plate is in the forward stroke the other will be in the back stroke. It is therefore nothing more than two single-plate feeders so connected that they operate together.

3 Mr. Bennett is mistaken regarding this type saving headroom over any other type. It requires about the same headroom as the plunger feeder (Fig. 9) and the reciprocating plate feeder (Fig. 10). The great drawback of the swinigng-plate feeder is that it is not self-cleaning, so that if exposed in winter the material will freeze to the bottom plate.

4 This type of feeder was originated by Mr. Lincoln Moss of New York, and the two installations mentioned by Mr. Bennett were designed by Mr. Moss under the writer's direction.

SPECIFIC VOLUME OF SATURATED STEAM

By Prof. C. H. Peabody,[1] Published in The Journal for May

ABSTRACT OF PAPER

The information now extant concerning the properties of saturated steam together with recent experiments presenting results of satisfactory precision, are recapitulated in this paper, and a computation of the specific volumes at various temperatures is made by the aid of the accepted thermodynamic equation and compared with experimental determinations of the same property. The greatest discrepancy between the computed and the experimental values for the specific volumes is shown to be 1/500. Since the essential properties of saturated steam enter into this discussion, the tables of the properties of steam computed from the data now available may be regarded as accurate.

DISCUSSION

Prof. William D. Ennis. The reason for the extrapolation of Fig. 3 is not quite clear to me. The ordinates of this diagram are differences between the Holborn and Henning values for the pressure of saturated steam, and those given by the Peabody formula, $\log p = a - b\,\alpha^{t-100} + c\,\beta^{t-100}$. The diagram is extended to include temperatures above 205 deg., the Holborn and Henning limit. Why would it not be just as satisfactory, if the Holborn and Henning values are satisfactory, to extrapolate directly the curve expressing their results?

2 There seems to be little room for uncertainty in any of the properties of saturated steam, excepting, possibly, the heat of the liquid. The maximum divergence in values for the former, comparing the Dieterici and the modified Regnault values adopted by Professor Peabody, occurs at the highest temperatures: at 220 deg. (an extrapolated point) it is 1.31 cal. or 0.584 per cent. Now if Dieterici does not claim an accuracy exceeding 0.5 per cent at this temperature, and since Professor Peabody admits a possible fractional percentage of error, the true value may be within the limit of estimated error in both computations. The result of taking Dieterici's values would be to make the computed specific volume 0.01 per cent less at 100 deg.,

[1] Prof. C. H. Peabody, Mass. Inst. of Tech. Dept. of Naval Architecture, Boston Mass.

0.02 per cent less at 140 deg. and 0.045 per cent less at 165 deg., than those tabulated on page 604. The deviation from the Knoblauch, Linde and Klebe results would be thus generally decreased. There is still a possibility that the Dieterici values may be more nearly correct. If the preponderance of error in values of the other quantities entering into the volume formula were in such a direction as to make the computed volumes too small, the lower heats of the liquid used by Professor Peabody might lead to an apparently better result because of a balancing of opposite errors. It does not seem safe to say definitely that such may not be the fact. The uncertainty in the heat of the liquid at 200 deg. is 0.36 per cent rather than 0.25 per cent. The same uncertainty applies to the entropy of the liquid, and a possible error of about 0.16 per cent to the entropy of vaporization. The entropy of saturation at this temperature may then be wrong to as great an extent as 0.23 per cent, or $\frac{1}{25}$. This would introduce a barely noticeable error into computations involving vapor cycles.

3 It is questionable whether permanence, in a matter of this kind, is as desirable as a standard, a flexible standard. Would it not be within the scope of the Society to coöperate with national engineering organizations abroad in the preparation of an international steam table for saturation and superheat, embodying the generally accepted values and subject to modification whenever an undisputed conclusion is reached on the one or two remaining doubtful quantities?

THE AUTHOR. In reply to Professor Ennis I will first explain that Holborn and Henning give a table of pressure for each degree of temperature, and make no use of an equation except as a means of fairing their results, for which purpose they chose Thiesen's equation which gives divergent values for higher temperatures. Now it happens that the equation which I chose gives value which converge toward Holborn and Henning's values so that it is possible to draw an extrapolation diagram as shown in my paper.

2 Secondly, I wish to say that Dr. Henning has kindly sent me in advance of publication an abstract of results which he has recently obtained for the heat of vaporization of water from 100 deg. to 180 deg. cent. His memoir will soon be available and will show that the results which I have deduced from Dr. Davis' values of the total heat, show a close concordance with these new experimental values. It is not unlikely that we may have a conclusive determination of the remaining quantity, heat of the liquid, but as stated in my paper the concordance of all quantities involved in the computation of steam

tables is even now very satisfactory so that there is no reason to anticipate any necessity for changing tables for engineers.

A NEW TRANSMISSION DYNAMOMETER

By Prof. Wm. H. Kenerson, Published in The Journal for May

ABSTRACT OF PAPER

The transmission dynamometer described in this paper was designed to meet the necessities of a problem requiring a dynamometer in the form of a shaft coupling. The construction of the instrument is shown, together with a number of its applications.

A stationary member provided with an oil-containing chamber, one side of which is a copper diaphragm, as in the Emery testing-machine, is placed between thrust bearings which are urged together by a force proportional to the torque in the shaft produced by a simple system of levers. A gage or other means of measuring the oil pressure in the chamber indicates the torque.

For use where the rate of rotation of the shaft is variable, a combination of gage and tachometer is shown, which will indicate horsepower, speed and torque.

The author mentions the following characteristics: *a* The instrument is compact. One shown in connection with a 3-in. shaft is about 13 in. in diameter and weighs about 160 lb.; *b* it is as rigid as an ordinary flange coupling; *c* it may be made in the form of a coupling, or of a quill on which a pulley is mounted; *d* it will indicate for either direction of rotation of the shaft; *e* the torque may be read or recorded or the work integrated at a considerable distance from the coupling; *f* no corrections are necessary for different rates of rotation; *g* it may be made very sensitive and accurate; *h* the amount of power absorbed is negligible; *i* the instrument is not easily deranged and is unaffected by temperature changes; *j* with suitable material and workmanship there is little likelihood of failure of any part of the instrument. In no case can it fail to drive the shaft or pulley to which it is attached.

DISCUSSION

A. F. Masury. I want to say a few words as to how the Kenerson dynamometer may be applied to the betterment of design in motor vehicles. In the first place, we must have exact data regarding the effect of road irregularities, wind pressures, and the resistances set up by grades and speed. These figures are absolutely necessary in

order to determine the best torque to apply on motor gearing and equipment, such as tires, etc., to overcome the existing conditions in each particular car.

2 At present we have two recourses: first, the figures procured by Mr. S. F. Edge at the Brooklands track in England with his Napier car. He first calibrated his motor and then made the test on the track. These figures must necessarily include many errors. Second, the dynamometer at the Automobile Club of America in New York. Here again satisfaction is not entirely procurable as all the road conditions are obtained artificially by attachments on the machine.

3 With the Kenerson dynamometer we can certainly get exact readings while the machine is working on the road. These can even be made graphic if desired. Manufacturers will thus have available means of getting information which should result in more perfect design.

4 There is one thing more, the dynamometer of the Automobile Club of America cost, I believe, in the vicinity of $15,000 by the time it was completely installed, while the price of the Kenerson machine, around $500, will make it possible for even a small manufacturer to get his own reading.

A UNIQUE BELT CONVEYOR

By Ellis C. Soper, Published in The Journal for May

ABSTRACT OF PAPER

This paper contains a description of the installation and operation of a belt conveyor, one-quarter mile long, built on practical lines, requiring less power to operate loaded than empty because the material is conveyed downhill. It is in actual operation at the present time, the only requisite labor being that of a boy to do the oiling and adjust the rolls, etc., which may get out of alignment.

DISCUSSION

T. A. Bennett. Mr. Soper's paper, while giving a practical description of a certain installation, hardly seems to warrant the word "unique." There are many conveyors in regular practice just as long—conveyors which run downhill—in fact, conveyors that need a brake. As for size, there is a 36-in. movable belt conveyor in New York over a thousand feet long, used for filling in the refuse from the

city on Riker's Island. The driving arrangement mentioned, from the receiving end of the conveyor, is also common practice.

2 Regarding the maximum length of conveyors, with a flat belt, as in this instance, the limit would be merely the cost of installation as practically any tensile strength desired can be obtained by increasing the number of plies of the belt. With a troughed belt the limit of length would be the tensile strength of the thickest belt that would conform to the trough of the idlers. This limit approaches somewhat the limits the author mentions, although such belts have been put in, as above, for lengths of a thousand feet or more.

3 His take-up has been in use for over five years in belt-conveyor practice. There is one installation at Bilbao, Spain, handling iron ore, which runs down an incline of 13 deg. and needs a brake, and has a counterweighted take-up working in a vertical plane. The take-up and drive are located on the return belt near the foot of the incline.

4 The tonnage of the conveyor is so small that the cost of maintenance per ton is also misleading. The wear of a belt is occasioned by the material coming in contact with it when delivered to it. A narrow stream of material permits each particle to come in contact with a small proportion of the total width, whereas a wide stream utilizes the full width of the belt and furthermore carries a large part of the material on top of the belt without ever touching it. I believe the capacity of this conveyor is something like 20 tons per hour, whereas such a conveyor should easily handle 200 tons per hour. Therefore the average cost for maintenance of the belt per ton carried is high.

HARRINGTON EMERSON. The last words in this paper are "The belt should last several years." In the last line of Table 4, it is stated that interest, depreciation and renewals amount to 10 per cent on an investment of $9200. Now, if the belt is to last only a few years, 10 per cent is not sufficient to cover interest, depreciation and renewal. Assuming that the belt lasts four years, the depreciation account alone would be $2300. That would increase the cost per ton from $0.02 to about $0.035.

FRED J. MILLER. It might be well to consider that there are other things that constitute part of this plant as well as the belt. As I understand, it is stated that the belt may last only a few years, but the rest of the plant may last enough longer than ten years to make 10 per cent a fair total charge for depreciation.

THE AUTHOR.[1] The belt conveyor in question has now been in operation about eighteen months, in which time less than $3.00 in repairs has been expended. The belt itself shows little wear and should last ten years. Of course the driving and carrying mechanisms will last indefinitely under ordinary conditions, as there is little wearing of the working parts, due to the slow speed of the belt.

2 The installation, as stated previously, though ample for a capacity of 200 tons per hour, is required to carry not over 20 tons per hour, and certainly the cost per ton for maintenance and other charges is out of proportion to what it would be were the belt carrying anything like full load.

3 The motor at the receiving end of the upper belt has been taken out and the belt has been driven for several months by the "lower" 10-h.p. motor, the "upper" belt being driven by the "quarter-twist" chain mentioned in the paper. To our knowledge, this is the *longest single-driven* belt conveyor (about 2150 ft.) in operation.

[1] Abstracted.

COMMENT ON CURRENT BOOKS

PRACTICAL ALTERNATING CURRENTS AND ALTERNATING-CURRENT TESTING. Charles F. Smith. *Scientific Publishing Company, Manchester, England.* Third edition, revised and enlarged, cloth, 6 by 9; XXI + 455 p.; 236 illustrations. Price 6s.

In this volume the author has endeavored to combine a text-book and a reference book for laboratory work. The experiments are described in detail so that the conclusions derived from them may be followed by anyone not having the means for performing the experiments. The use of higher mathematics has been avoided as far as possible.

Contents by chapter headings: Alternating Electromotive Force and Current; Impedance; Power and Power-Factor; Virtual Value of an Alternating Current; Effect of Capacity; The Transformer; Alternators; Synchronous Motors; The Polyphase Circuit; The Rotary Converter; The Polyphase Induction Motor; Single-Phase Motors; The Composition of Waves.

SIMPLIFIED METHODS OF CALCULATING REINFORCED CONCRETE BEAMS. By W. Noble Twelvetrees. *The Macmillan Company, New York,* 1909. Paper, 5 by 7; 20 p.; 10 illustrations. Price 20 cents.

The author has assembled a number of formulæ from different authorities on reinforced-concrete beams, and has re-stated each formula in terms of a uniform set of symbols. He also presents what are termed "labor-saving" diagrams and describes a calculating instrument for use in reinforced-concrete design.

BRENNAN'S HANDBOOK, A Compendium of Useful Legal Information for Business Men. By B. A. Brennan *John Wiley & Sons, New York,* 1908. Leather, 4½ by 7; 571 p. Price $5.

The author's position as contract manager of the Westinghouse Machine Company, of Pittsburg, Pa., has made necessary a knowledge of the laws on contracts and other instruments for recording, buying and selling transactions. The book is not presented as a final authority on the matters treated but rather as a source of information to enable business men to become familiar with the fundamental principles of business law. A valuable feature is a synopsis of the statutes bearing on the collection laws of the different States. A number of useful legal forms are also given.

Contents by chapter headings: Contracts in general; Sales Contracts; Property—Deeds—Mortgages—Liens—Insurance; Acknowledgments—Power of Attorney—Licenses—Guarantee, Etc.; Notes— Checks—Interest; The Negotiable Instruments Law; Synopsis of Statutes on Conditional Sales—Chattel Mortgages—Mechanics' Liens—Bills and Notes—Forms of Acknowledgments; Collection Laws Tabulated; Legal Forms.

GAS ENGINE THEORY AND DESIGN. By A. C. Mehrtens, M.E. *John Wiley & Sons, New York,* 1909. Cloth, 5½ by 8; V + 256 p.; numerous tables and illustrations. Price $2.50.

To make this book of interest to students, draftsmen, engineers, and men operating engines, the treatment has been somewhat elementary. Following out this

idea, also, considerable space—nearly one-half the book—is devoted to design of parts. Complete working drawings are given for a 2½-h.p. marine engine and a ½-h.p. horizontal engine.

Contents by chapter headings: General Principles of Operation; Historical; Applications of the Gas Engine; Heat—Thermodynamics; Combustion; Fuels; Laws of Gases; Gas Engine Efficiency; Explosive Mixtures; Mixing Valves and Carbureters; Governing; Ignition; Cooling; Exhaust; Selection of Type; Determination of the Principal Dimensions; Forces Acting in the Gas Engine; Design and Dimensions of Parts; Gas Engine Manipulation; Testing; Designs.

APPLIED MECHANICS FOR ENGINEERS. By E. L. Hancock. *The Macmillan Company, New York*, 1909. Cloth 5 by 7½; XI + 385 p., 205 illustrations, Price $2.

The author, who is assistant professor of applied mechanics at Purdue University, has sought to make the book different from others on the subject by giving examples to show the application of theory to practical problems. While it is primarily a text-book, the method of presentation in the chapters on moment of inertia, center of gravity, work and energy, friction and impact, make it of value to the engineer. Convenient tables of logarithms, trigonometric functions, etc., are given at the end of the book.

Contents by chapter headings: Definitions; Concurrent Forces; Parallel Forces; Center of Gravity; Couples; Non-Concurrent Forces; Moment of Inertia; Flexible Cords; Rectilinear Motion; Curvilinear Motion; Rotary Motion; Dynamics of Machinery; Work and Energy; Friction; Impact.

BRICKLAYING SYSTEM. By Frank B. Gilbreth, Mem.Am.Soc.M.E. *Myron C. Clark Publishing Co., New York.* Cloth, 6 by 9; XI + 321 p., 167 illustrations, 73 charts. Price $3.

The author has endeavored to put in writing that knowledge which has been handed down by word of mouth from journeyman to apprentice for generations. The various operations in the laying of brick are described and illustrated in great detail. He has also given the rules followed in developing and handling his men, in handling material and in methods of construction. The addition of data on costs and cost systems would doubtless increase the value of the book.

Contents by chapter headings: Training Apprentices; Methods of Management; Methods of Construction; Routing of Material; Scaffolds; The Gilbreth Scaffold-Hod Type; The Gilbreth Scaffold-Packet Type; The Gilbreth Packet System; Method of Building Tall Chimneys; Mortar; Bricks; Bricklayers' Tools, etc.; Lines, Plumbs and Poles; Motion Study; Methods of Laying Brick under Special Conditions; Finishing, Jointing and Pointing; Arches and Chimney Breasts; Tearing Down, Cutting out and Patching Brickwork; Bond.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society who are capable of filling responsible positions. Information will be sent upon application.

MEN AVAILABLE

300 Mechanical and electrical engineer desires position (east preferred) as assistant to mill engineer or manager of works on the design and equipment of power plants and industrial works. Age 43. Has had six years' experience as engineer of works with two important manufacturing companies.

301 Construction engineer, eleven years' experience in design and erection of every kind of building, construction, installation of machinery and equipment, desires permanent position with manufacturing concern doing their own work in enlarging and improving their factories, to take entire charge. Best references.

302 Member, broad experience in constructing, erecting and operating.

303 Associate member, graduate mechanical engineer with ten years experience in industrial and architectural engineering, now open to engagement designed and constructed several large power and industrial plants.

304 Junior member, Stevens graduate, desires to make a change. Nine years practical experience in machine-tool, steam and electric machinery; power plants. Good systematizer and familiar with up-to-date shop practice and management New York district preferred.

305 Associate member, consulting mechanical engineer, having completed recent investigation and report leading to important economy of fuel in large factory plant, is now open for a similar engagement. Eight years of practice in reducing power and heating costs in factories.

306 Graduate mechanical engineer, Junior member, desires position with automobile concern which will yield experience in all branches of the business and afford opportunity for advancement. Experienced especially in automobile and electrical engineering; can demonstrate and sell, design and superintend construction.

307 Manual training and University technical graduate; age 33; thirteen years practical experience in machine shop, drafting, designing, testing, estimat-

ing, etc.; has employed and had charge of men; desires position of some responsibility (preferably in Philadelphia, or vicinity); would consider opportunity in the commercial line of engineering or manufacturing.

308 Mechanical engineer with shop experience as molder, pattern-maker, machinist and draftsman; has been engaged on new design and revision of existing designs for more economical production, also devising shop methods and tools and as superintendent of manufacturing plant turning out a line of medium-weight machinery, desires position in which such experience would be of value.

309 Position as superintendent, assistant superintendent, or general foreman. Age 37. Fifteen years office and shop experience in smith and machine shop. as chief draftsman, salesman and superintendent. Good references. Moderate salary acceptable.

310 Junior member, technical graduate of four years standing, American; married; experience in Spanish-speaking country; speaks Spanish, German, Russian and some French; wishes employment with firm having European or Latin-American connections.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS.

ARMSTEAD, F. C. (1906), care of Westinghouse Mch. Co., Attica, N. Y.

BAKER, Dickerson G. (1905), Wks. Mgr., Blake & Knowles Steam Pump Wks., East Cambridge, and *for mail*, 11 Mt. Pleasant St., Winchester, Mass.

BAUSCH, F. E. (1904), Mgr., Hooven, Owens, Rentschler Co., 1316 Chemical Bldg., St. Louis, Mo.

BERG, Hart O. (1898; 1903), Engr., 72 Victoria St., Westminster, S. W., London, England; and 32, Ave. Champs Elysées, Paris, France.

BEVERLEY, Richard Carter (Junior, 1906), Partner, W. P. Longworth & Co., Engrs. and Contrs., and *for mail*, 611 E. Franklin St., Richmond, Va.

BILLINGS, A. W. K. (1909), care J. G. White & Co., Inc., 43 Exchange Pl., New York, N. Y.

BRAUN, Carl F. (Junior, 1907), Mgr., Standard Engrg. Co., 503 Market St., San Francisco, Cal.

BRECKENRIDGE, L. P. (1890), V. P., 1907–1909; Prof. Mech. Engrg. Sheffield Scientific Sch., New Haven, Conn.

BRESLOVE, Joseph (Junior, 1906), Westinghouse Mch. Co., East Pittsburg, and *for mail*, cor. Emerson and Alder Sts., E.E., Pittsburg, Pa.

CHAMBERLAIN, Harry M. (1907), 17 Wrentham St., Dorchester Center, Mass.

COLE, Cyrus L. (Junior, 1908), 619 Walker St., Milwaukee, Wis.

CUMMINGS, Edgar C. (1906), Gooding, Lincoln Co., Idaho.

DAVIS, A. C. (1909), care of Penna. Lines, Wellsville, O.

FITCH, Alfred L. (Associate, 1907), Charge of Spec. Mchy. Design, Western Elec. Co., 259 S. Clinton St., and *for mail*, 1132 E. 45th St., Chicago, Ill.

FOSTER, Charles F. (1890), 416 W. Indiana St., and *for mail*, 317 S. Irving Ave., Chicago, Ill.

FRITZ, A. L. G. (Junior, 1907), Ford, Bacon & Davis, 115 Broadway, New York, and 99 Elmwood St., Woodhaven, L. I., N. Y.

GANTT, Henry L. (1888), Manager, 1908–1911; Cons. Engr., 120 W. 57th St., New York, N. Y.

GILLIES, Wm. F. (Junior, 1905), Box 286, Douglas, Ariz.

GOLDINGHAM, Arthur Hugh (1907), De La Vergne Mch. Co., Foot E. 138th St., and *for mail*, 552 Riverside Drive, New York, N. Y.

HATHAWAY, H. K. (Associate, 1908), V. P., Tabor Mfg. Co., 18th and Hamilton Sts., Philadelphia, Pa.

HAUGHTON, Frank A. (1903), Genl. Supt., Taylor Iron and Steel Co., High Bridge, N. J.

HAZELTON, William S. (1909), 475 Second Ave., Detroit, Mich.

HELVEY, Clarence H. (Junior, 1905), Hamilton Engrg. Co., Hamilton, O.

HENNING, Gustavus C. (1880), Manager, 1896–1899; Life Member, 1890; Cons. Engrg., 150 Nassau St., and *for mail*, 413 Convent Ave., New York, N. Y.

HOLCOMB, A. Elton (Junior, 1901), V. P. and Mgr., Earth Moving Machinery Co., and *for mail*, 4323 W. Van Buren St., Chicago, Ill.

HOLLOWAY, Thurman Welford (Junior, 1906), International Corr. Schools, Ltd., Kingsway, London, W. C., England.

IRELAND, M. L. (Junior, 1902), Coast Artillery Corps, Fort Stevens, Ore.

JOHNSON, Lewis (1880), Pres., Johnson Iron Wks. (Ltd.), P. O. Drawer 241, New Orleans, La.

JOHNSON, Louis L. (1908), Gas Engr. Elec. Dept., Southern Pacific Co., Room 1110, Flood Bldg., San Francisco, Cal.

JOHNSON, Paul F. (1905), Monadnock Bldg., San Francisco, Cal.

JORDAN, Wm. Allen (Junior, 1903), Chas. Warner Co., Wilmington, Del.

MACLAREN, James G. (Associate, 1908), Engr., Lamson Cons. Store Service Co., 225 5th Ave., New York, and *for mail*, P. O. Box 541, Harrison, N. Y.

MILLER, John S. (1900; 1907), Yuba Const. Co., Marysville, Cal.

MINCK, Peter (Junior, 1909), Mech. Engr. with Edwin Burhorn, 71 Wall St., New York, N. Y., and 112 Gardner St., Union Hill, N. J.

PENNOCK, George Alger (Junior, 1903), Asst. Supt., Service and Maintenance, West. Elec. Co., Hawthorne, and *for mail*, 4012 Jackson Blvd., Chicago, Ill.

POMEROY, Harry D. (1892; 1904), Supt. and Mgr., M. C. Ryan Co., Phoenix, N. Y.

SANGUINETTI, Percy A. (1886), Cons. Engr., 335 S. First Ave., Mt. Vernon, N. Y.

SHANTZ, O. S. (1900), care of Shantz Mfg. Co., and *for mail*, 475 Norwood Ave., Buffalo, N. Y.

SHARPE, Henry D. (Associate, 1901), Treas., Brown & Sharpe Mfg. Co., and *for mail*, 130 Angell St., East Side Sta., Providence, R. I.

SHIRLEY, Robert (1906), Wks. Mgr., Chapman Valve Mfg. Co., Indian Orchard, Mass., and *for mail*, 26 Lennox St., Hartford, Conn.

SMITH, Chas. F. (1889), Cons. Elec. and Mech. Engr., 25 City Hall Pl., 10th Floor, New York, and 252 Carlton Ave., Brooklyn, N. Y.

SMITH, Roy B. (Junior, 1905), 2213 Adams Ave., Norwood, Cincinnati, O.

SPONSLER, Charles Fred'k (Junior, 1904), Ch. Engr., Bureau of Standards, Dept. of Commerce and Labor, and *for mail*, 1644 Park Rd., Washington, D. C.

STARKWEATHER, Wm. G. (1897), 53 State St., Boston, and 17 Gibson Rd., Newtonville, Mass.

STRATTON, H. F. (Junior, 1904), Sales Mgr., Elec. Controller & Mfg. Co., and *for mail*, Suite 7, 1523 E. Blvd., Cleveland, O.

SWAIN, George F. (1883), Prof. Civ. Engrg., Graduate Sch. Applied Science, Pierce Hall, Oxford St., Harvard Univ., Cambridge, Mass.

TAGGE, Arthur C. (1901), Ch. Engr., Eastern Canada Portland Cement Co., Dombourg, P. Q., Canada.

TALCOTT, Robt. Barnard (1907), Asst. Ch. Mech. and Elec. Engr., Office of Supervising Arch., Treas. Dept., and *for mail*, 3038 Dunbarton Ave., N. W., Washington, D. C.

TROTZ, J. O. E. (1906) Svanevik, Ronneby, Sweden.

TUCKER, Edwin D. (1898), Mech. Engr., 189 6th Ave., New York, N. Y.

ULBRICHT, T. C. (Junior, 1908), Instr. Engrg. Dept., Pratt Inst., and *for mail*, 170 St. James Pl., Brooklyn, N. Y.

VAN DEINSE, A. F. (Junior, 1905), 123 San Francisco St., El Paso, Tex.
VOSE, Fred Hale (Junior, 1906), Mech. Engrg. Dept., Case Sch. Applied Science and *for mail*, 10521 Lee Ave., N. E., Cleveland, O.
WHEELER, Chas. Van Cise (1906), Supt., Projectile Dept., Firth-Sterling Steel Co., P. O. Box 812, and *for mail*, 1609 16th St., N. W., Washington, D. C.
WHITE, James A. (Junior, 1900), 22 Atlantic St., Lynn, Mass.
WILLIAMS, George W. (1904; 1907), Asst. Engr., Geo. M. Brill, 1134 Marquette Bldg., and *for mail*, 365 E. 59th St. Chicago, Ill.
WINSHIP, W. E. (1909), Cor. 179th St. and Fort Washington Ave., New York, N. Y.

DEATHS

BLAIR, Archibald W.

NEW MEMBERS

BAILEY, H. Morell (Junior, 1909), 523 Somerset St., Johnstown, Pa.
FARWELL, E. S. (1899), 309 Broadway, New York, N. Y.
FLETCHER, E. Leslie (1909), Court Exchange, Bridgeport, Conn.
GIFFORD, Byron T. (Junior, 1909), 407 First Natl. Bank Bldg., Chicago, Ill.
McGLONE, Roy G. (Junior, 1909), Ch. Engr., U. S. Dredge Guadalupe, Victoria, Tex.
SCHEEL, Henry V. R. (Junior, 1909), Brighton Mills, and *for mail*, 205 Van Houten Ave., Passaic, N. J.
STANTON, Francis A. O'C. (Junior, 1909), 1104 Bloomfield St., Hoboken, N. J.
TREFTS, John C. (1909), Farrar & Trefts, 54–56 Perry St., Buffalo, N. Y.
WEGG, David S. (Junior, 1909), Secy. to Head of Telluride Inst., Olmsted, Provo, Utah.

PROMOTIONS

SHIEBLER, Marvin (1905–1909), Stone & Webster Engrg. Corp., Boston, Mass., and *for mail*, 30 Church St., New York, N. Y.

GAS POWER SECTION

CHANGES OF ADDRESS

GOLDINGHAM, Arthur H. (1909), De La Vergne Mch. Co., Foot E. 138th St., and *for mail*, 552 Riverside Drive, New York, N. Y.

McNEIL, Merritt C. (Affiliate, 1909), Janette Ct., Millvale and Ben Venue Ave., Pittsburg, Pa.

SHOOP, R. B. (Affiliate, 1908), 511 De Kalb Ave., De Kalb, Ill.

ULBRICHT, T. C. (1908), Instr. Engrg. Dept., Pratt Inst., and *for mail*, 170 St. James Pl., Brooklyn, N. Y.

VOSE, Fred Hale (1909), Mech. Engrg. Dept., Case Sch. Applied Science, and *for mail*, 10521 Lee Ave., N. E., Cleveland, O.

NEW MEMBERS

BERG, P. Eskil (Affiliate, 1909), Engr. Turbine Dept., Genl. Elec. Co., Schenectady, N. Y.

FINLAY, Lance Geo. (Affiliate, 1909), Mgr., L. G. Finlay & Co., New England Bldg., Cleveland, O.

FISKE, Geo. Wallace (Affiliate, 1909), Mech. Engr., 480 E. 22d St., Oakland, Cal.

LITZ, Earl Ewing (Affiliate, 1909), Genl. Mgr., Combustion Util. Co., 60 Wall St., New York, N. Y.

STUDENT SECTION

CHANGES OF ADDRESS

CRAIG, Ollison (Student, 1909), 1143 Portland Pl., Boulder, Colo.

DAUGHERTY, R. L. (Student, 1909), 415 Lytton Ave., Palo Alto, Cal.

EIDMANN, Frank L. (Student, 1909), P. O. Box 173, Lansing, Mich.

MUDD, John P. (Student, 1909), 2101 W. Tioga St., Philadelphia, Pa.

COMING MEETINGS

OCTOBER AND NOVEMBER

Secretaries or members of societies whose meetings are of interest to engineers are invited to send in their notices for publication in this department. Such notices should be in the editor's hands by the 18th of the month preceding the meeting.

ALABAMA LIGHT AND TRACTION ASSOCIATION
November 15, 16, annual convention, Birmingham. Secy., Lloyd Lyon, 158 Government St., Mobile.

AMERICAN CHEMICAL SOCIETY, New York Section
October 8, 108 W. 55th St. Paper: Partial Vapor-Pressures of Binary Mixtures. Secy., C. M. Joyce.

AMERICAN CIVIC ASSOCIATION
November 15–19, Cincinnati, O. Secy., Richard B. Watrous, Harrisburg, Pa.

AMERICAN GAS INSTITUTE
October 20–22, Hotel Pontchartrain, Detroit, Mich. Secy., A. B. Beadle, 25 West 39th St., N. Y.

AMERICAN MINING CONGRESS
September 27–October 2, Goldfield, Nev. Papers on Silver Exchange. Secy., J. F. Callbreath, Jr., Denver, Colo.

AMERICAN PUBLIC HEALTH ASSOCIATION
October, Richmond, Va. Secy., C. O. Probst, Columbus, O.

AMERICAN RAILWAY ASSOCIATION
November 17, Chicago, Ill. Secy., W. F. Allen, 24 Park Pl., New York.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION
October 19–21, annual convention, Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine Ry., Concord, N. H.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
October 12, November 9, monthly meetings, 29 W. 39th St., New York; October 16, St. Louis, Mo.; October 20, Boston, Mass. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS
November 9–11, annual meeting, Little Rock, Ark. Secy., A. Prescott Folwell, 239 W. 39th St., New York.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION
October 4–8, annual convention, Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York.

ASSOCIATION OF CAR LIGHTING ENGINEERS
October 5–8, annual convention, Chicago, Ill. Secy., G. B. Colegrove, 6250 Drexel Ave., Chicago, Ill.

CAR FOREMEN'S ASSOCIATION OF CHICAGO
October 11, annual meeting. Secy., Aaron Kline, 326 N. 50th Court.

CENTRAL RAILWAY CLUB

November 12, Hotel Iroquois, Buffalo, N. Y., 8 p.m. Paper: Application of Electricity to the Movement of Freight, G. H. Condict. Secy., H. D. Vought.

CENTRAL RAILWAY AND ENGINEERING CLUB OF CANADA

October 19, November 16, Prince George Hotel, Toronto, Ont. Papers: Care and Maintenance of Elevators, J. Shales; Gas Engines, their Origin and Commercial Use, G. M. Henderson. Secy., C. L. Worth, Union Sta.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION

October 7–9, annual convention, Denver, Colo. Papers: The Commercial Field; Meters and Testing; Lamps and Illumination. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

EMPIRE STATE GAS AND ELECTRIC ASSOCIATION

November 17, 18, 29 West 39th St., New York. Secy., C. H. B. Chapin.

MODERN SCIENCE CLUB

October 12, semi-annual meeting; October 19, Paper: Air Compressors, S. B. Redfield; October 26, Paper: Power, F. L. Johnson. Secy., J. A. Donnelly, 125 S. Elliott Pl., Brooklyn, N. Y.

NATIONAL MUNICIPAL LEAGUE

Week of November 15, Cincinnati, O. Secy., C. R. Woodruff, 121 S. Broad St., Philadelphia, Pa.

NEW ENGLAND RAILROAD CLUB

October 12, Copley Square Hotel, Boston. Paper: Railroad Operating Statistics, William J. Cunningham. Secy., Geo. H. Frazier, 10 Oliver St.

NEW YORK RAILROAD CLUB

November 19, annual meeting, 29 W. 39th St. Secy., H. D. Vought, 95 Liberty St.

OHIO SOCIETY MECHANICAL ELECTRICAL & STEAM ENGINEERS

November 19, 20, main annual meeting, Lima, O. Secy David Gaehr, Schofield Bldg., Cleveland.

RAILWAY CLUB OF PITTSBURG

October 22, annual meeting, Monongahela House. Secy., J. D. McIlwain, care P. & L. E. R. R.

RAILWAY SIGNAL ASSOCIATION

October 12–14, Louisville, Ky. Secy., C. C. Rosenberg, 712 North Linden St., Bethlehem, Pa.

RICHMOND RAILROAD CLUB

November 8, annual meeting. Secy., F. O. Robinson.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA

October 5–7, Toronto. Secy., Alcide Chausse, R.S.A., P. O. Box 259, Montreal, Que.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS

November 18, 19, 29 W. 39th St., New York. Secy., W. H. Baxter.

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB

November 18, annual meeting, Candler Bldg., Atlanta, Ga. Papers on Oil Lamps, Front-End Arrangements, Draft-Rigging. Secy., A. J. Merrill, 218 Prudential Bldg.

TECHNICAL SOCIETY OF BROOKLYN

October 1, annual meeting, Arion Hall, Arion Pl., 8.30 p.m. Pres., M. C. Budell, 20 Nassau St., New York.

TECHNICAL SOCIETY OF WASHINGTON

October 6, annual meeting, 314 C St. N. W. Secy., Paul Bausch.

WESTERN ASSOCIATION OF ELECTRICAL INSPECTORS

October 26-28, annual meeting, Detroit, Mich.

WESTERN SOCIETY OF ENGINEERS

October 6, 20, November 3, 20, 1735 Monadnock Blk., Chicago, Ill. Papers: Wood Preservation; Hydraulic Mining of Auriferous Gravels, J. W. Phillips; Loss of Heat through Furnace Walls, W. T. Ray, Henry Kresinger; The Panama Railroad, Ralph Budd.

MEETINGS TO BE HELD IN ENGINEERING SOCIETIES' BUILDING

Date October	Society	Secretary	Time
1	Explorers' Club	H. C. Walsh	8.30
2	Amer. Soc. Hungarian Engrs. & Archts	Z. deNemeth	8.30
6	Wireless Institute	S. L. Williams	7.30
7	Blue Room Engineering Society	W. D. Sprague	8.00
8	American Institute Electrical Engrs	R. W. Pope	8.00
12	The American Society of Mech. Engrs	C. W. Rice	8.00
14	Illuminating Engineering Society	P. S. Millar	8.00
15	New York Railroad Club	H. D. Vought	8.15
19	New York Telephone Society	T. H. Lawrence	8.00
27	Municipal Engineers of City of New York	C. D. Pollock	8.15
November			
3	Wireless Institute	S. L. Williams	7.30
4	Blue Room Engineering Society	W. D. Sprague	8.00
5	Explorers' Club	H. C. Walsh	8.30
6	Amer. Soc. Hungarian Engrs. and Archts	Z. deNemeth	8.30
9	The American Society of Mech. Engrs	C. W. Rice	8.00
11	Illuminating Engineering Society	P. S. Millar	8.00
12	American Inst. Electrical Engrs	R. W. Pope	8.00
16	New York Telephone Society	T. H. Lawrence	8.00
17–18	Empire State Gas & Elec. Assoc.	C. H. B. Chapin	All day
18–19	Naval Architects and Marine Engrs	W. H. Baxter	All day
19	New York Railroad Club	H. D. Vought	8.15
24	Municipal Engineers of City of New York	C. D. Pollock	8.15

ACCESSIONS TO LIBRARY

BOOKS

Association of Railway Telegraph Superintendents. Proceedings of the Annual Meeting, 1909. *Milwaukee, Wis., 1909.* Gift.

Association of Transportation and Car Accounting Officers. *Proceedings.* Eleventh Meeting, June 1909. *Montreal, Que., 1909.* Gift.

Cambridge (Mass.) Water Board. Annual Report, December 1, 1907–April 1, 1909. *Cambridge, 1909.* Gift.

Castings Directory. 1908. *Cleveland, O., 1908.* Gift of Gardner Printing Co.

Commission on Additional Water Supply for the City of New York. Report of Department of Pumping, November 30, 1903. *New York,* 1904.

Definition el la Mésure Industriellé de L'Acceleration des Trains By C. O. Mailloux. *Paris, 1908.* Gift of author.

Kansas State Agricultural College. Forty-Sixth Annual Catalogue, 1908–1909. *Topeka, Kan., 1909.* Gift.

Metallographie. By Dr. W. Guertler. Vol. 1. *Berlin, Gebruder Borntraeger, 1909* Gift of publishers.

Municipal Engineers of the City of New York. *Proceedings, 1908. Neu York, 1909.* Gitf.

New Orleans Sewerage and Water Board. Eighteenth Semi-Annual Report. *New Orleans, La., 1908.* Gift.

Notes on Explosive Mine Gases and Dusts. By R. T. Chamberlin. (Bulletin No. 383, U. S. Geological Survey.) *Washington, Govt., 1909.* Gift.

Osterreichischen Ingenieur-und Architekten Vereines. XXXVIII Verzeichnis der Mitglieder. *Vienna 1909.* Gift.

Pacific Municipalities. Vol. 21. No. 1. *San Francisco, Cal., 1909.* Gift of the League of California Municipalities.

Pan-American Scientific Congress. Report of Delegates of the United States. *Washington, Govt.,* 1909.

Railway Signal Association. *Gift. Proceedings.* Vol. 3, 1906; Vol. 5, 1908.

Reinforced Concrete Design, Extracts from Concrete, Plain and Reinforced, 2d Ed. By F. W. Taylor and S. E. Thompson. *New York, 1909.* Gift of authors.

Smokeless Combustion of Coal in Boiler Plants. By D. T. Randall and H. W. Weeks. (Bulletin No. 373, U. S. Geological Survey.) *Washington,* Govt., 1909. Gift.

First International Congress of the Refrigerating Industries, Paris, October 5-12, 1908

Gift of Gardner T. Voorhees

Programs in French, German and English.

Summaries in French, German and English of papers and reports presented to the general secretary before August 28, 1908. *Paris, 1908.*

REPORTS AND PAPERS contained in pamphlet, Fabrication des Gobelets en Glace, by Brevet Huizier; Meat Trades Journal and Cattle Salesman's Gazette, *London, October 1, 1908;* Zeitschrift für die Gesamte Kälte-Industrie, September 1908; La Glace et les Industries du Froid, *April 1907, May 1908;* La Bière et les Boissons Fermentées, *July 15, September 15, 1907;* Ice and Cold Storage, *October 1908;* L'Événément, L'Evénément Illustré, *October 5, 1908;* Société du Froid Industriel, *March 1908;* L'Édilité Technique, *September 1908,* Le Nouvel Abattoir de Soissons

HOLZIMPRÄGNIERUNG. Val. Allut Noodt. *Paris, 1908.*

REPORTS on the Refrigerating Industries in Great Britain, *London, 1908;* France, *October, 1908;* Germany, *Munich and Berlin,* 1908; Hungary, *Budapest, 1908;* Italy, *Rome, 1908;* New Zealand, *Wellington, 1908;* Argentine Republic, *Paris,* 1908.

Catalogues

BRÜNN-KÖNIGSFELDER MASCHINENFABRIK. Paraffin-Kühlanlage für die Mineralol Raffienerie "Schodnica" in Dzieditz.

COMPAGNIE DES EPURATEURS KENNICOT. Epuration, filtration et distillation des eaux.

B. LEBRUN. Machines du froid et de la Glace, moteurs a gaz pauvre, et pétrole.

B. LEBRUN, *Paris.* Ice and refrigeration machinery, refrigerating plant installations.

L. ROUSSEAU ET CIE. La construction des installations frigorigues.

MILLE & POURCEL, *Paris.* Ice machines, gas and gasolene engines for refrigerating plants, refrigerating machinery.

SOCIÉTÉ ANONIMA PER FRIGORIGENI MOTORI. "Motorfrigors" (Motors).

SULZER FRFRES. La nouvelle installation frigorigue des glacières de l'alimentation à Paris.

EXCHANGES

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. *Transactions.* Vol. 13. *New York,* 1908.

ENGINEERING OF ORDNANCE. By A. T. Dawson. *London, 1909.* (Supplement to Vol. 19 of Transactions of the Junior Institution of Engineers.)

INCORPORATED INSTITUTE OF AUTOMOBILE ENGINEERS. Report of Proceedings, Session of 1907–1908. Vol. 2. *London,* 1908.

INDEX TO THE REPORTS OF THE COMMISSIONER OF EDUCATION. 1867–1907. *Washington, 1909.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings. Vol. 176. *London, 1909.*

MINING INSTITUTE OF SCOTLAND. List of Members. 1908–1909. *Hamilton,* 1909.

YALE UNIVERSITY. Report of the President, 1909. *New Haven, Conn.,* 1909.

TRADE CATALOGUES

SIMS CO., *Erie, Pa.* Steam separator for vertical and horizontal pipe; bulletins of power-plant appliances, as feed-water heaters, sheet-iron exhaust-heads,

hot-water generators, steam separators, water softeners, oil separators, etc.; folder, May 22, 1909, purchasers of Sims feed-water heaters and hot-water generators.

CENTURY ELECTRIC CO., *St. Louis, Mo.* Single-phase motors.

JOSEPH T. RYERSON & SON, *Chicago, Ill.* Monthly stock lists of machinery, iron and steel material.

SCULLY STEEL AND IRON CO., *Chicago, Ill.* Stock list of bolts, screw punches, blacksmith's vises, etc.

GENERAL ELECTRIC CO., *Schenectady, N. Y.* Folders on feeder-regulators, fan-motors, measuring instruments, new G. E. Tungsten lamp for economic consumption, Edison gem lamps for standard multiple-lighting circuits, Tungsten lamp installation, various applications. Bulletin No. 4665, Electrical operation of pulp and paper mills; No. 4675, Single-phase motors, type RI; No. 4677, Sprague G. E. type M control system; No. 4680, Sign lighting with G. E. Tungsten lamps; No. 4687, direct-current motor-starting rheostats CR-107 and CR-111; No. 4688, Compound meter board non-inflammable, non-cracking or warping, etc.

NATIONAL ELECTRIC LAMP ASSOCIATION, *New York.* Advantages of Tungsten lamp.

T. RICHARD, *80 Rue Taitbout, Paris.* Conveying machinery, overhead cranes, and coal-handling machinery.

UNDERFEED STOKER CO. OF AMERICA, *Chicago, Ill.* Publicity Magazine, August 1909.

UNITED ELECTRIC LIGHT AND POWER CO., *New York.* Light, August 1909.

WESTINGHOUSE ELECTRIC AND MFG. CO., *Pittsburg, Pa.* Folders on Type D, Type A automatic mercury-rectifier battery-charging outfit, fans, electric motors, electric power for domestic purposes, reading meters, 8-in. fan motors for alternating and direct current. Circular No. 1079, O. I. W. C. trans ormers; No. 1144, direct-current mill motors; No. 1163, Type DA small motors; No. 1164, Type MS mill motors polyphase lternating-current circuits.

WHITEHALL PORTLAND CEMENT CO., *Philadelphia, Pa.* Cementology, June and July 1909.

OFFICERS AND COUNCIL

PRESIDENT

JESSE M. SMITH ..... New York

VICE-PRESIDENTS

L. P. BRECKENRIDGE ..... Urbana, Ill.
FRED J. MILLER ..... Center Bridge, Pa.
ARTHUR WEST ..... E. Pittsburg, Pa.

Terms expire at Annual Meeting of 1909

GEO. M. BOND ..... Hartford, Conn.
R. C. CARPENTER ..... Ithaca, N. Y.
F. M. WHYTE ..... New York

Terms expire at Annual Meeting of 1910

PAST PRESIDENTS

Members of the Council for 1909

AMBROSE SWASEY ..... Cleveland, O
JOHN R. FREEMAN ..... Providence, R. I
FREDERICK W. TAYLOR ..... Philadelphia, Pa.
F. R. HUTTON ..... New York
M. L. HOLMAN ..... St. Louis, Mo.

MANAGERS

G. M. BASFORD ..... New York
A. J. CALDWELL[1] ..... Newburg, N. Y.
A. L. RIKER ..... Bridgeport, Conn.

Terms expire at Annual Meeting of 1909

WM. L. ABBOTT ..... Chicago, Ill.
ALEX. C. HUMPHREYS ..... New York
HENRY G. STOTT ..... New Rochelle, N. Y.

Terms expire at Annual Meeting of 1910

H. L. GANTT ..... New York
I. E. MOULTROP ..... Boston, Mass.
W. J. SANDO ..... Milwaukee, Wis.

Terms expire at Annual Meeting of 1911

TREASURER

WILLIAM H. WILEY ..... New York

HONORARY SECRETARY

F. R. HUTTON ..... New York

CHAIRMAN OF THE FINANCE COMMITTEE

ARTHUR M. WAITT ..... New York

SECRETARY

CALVIN W. RICE ..... 29 W. 39th Street, New York

[1]Deceased,

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ALEX. C. HUMPHREYS — FRED J. MILLER
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EDWARD F. SCHNUCK (2) — ROBERT M. DIXON (4)
WALDO H. MARSHALL (5)

HOUSE

HENRY S. LOUD (1) *Chairman* — BERNARD V. SWENSON (3)
WILLIAM CARTER DICKERMAN (2) — FRANCIS BLOSSOM (4)
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LIBRARY

JOHN W. LIEB, JR. (4), *Chairman* — AMBROSE SWASEY (2)
H. H. SUPLEE (1) — LEONARD WALDO (3)
CHAS. L. CLARKE (5)

MEETINGS

WILLIS E. HALL (1), *Chairman* — L. R. POMEROY (3)
WM. H. BRYAN (2) — CHARLES E. LUCKE (4)
H. DE B. PARSONS (5)

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D. S. JACOBUS (2) — H. W. SPANGLER (4)
GEO. I. ROCKWOOD (5)

RESEARCH

W. F. M. GOSS (5), *Chairman* — R. C. CARPENTER (2)
JAS. CHRISTIE (1) — R. H. RICE (3)
CHAS. B. DUDLEY (4)

NOTE.—Numbers in parentheses indicate length of term in years that the member has yet to serve.

SPECIAL COMMITTEES
1909

On a Standard Tonnage Basis for Refrigeration

D. S. Jacobus — G. T. Voorhees
A. P. Trautwein — Philip De C. Ball
E. F. Miller

On Society History

John E. Sweet — H. H. Suplee
Chas. Wallace Hunt

On Constitution and By-Laws

Chas. Wallace Hunt, *Chairman* — F. R. Hutton
G. M. Basford — D. S. Jacobus
Jesse M. Smith

On Conservation of Natural Resources

Geo. F. Swain, *Chairman* — L. D. Burlingame
Charles Whiting Baker — M. L. Holman
Calvin W. Rice

On International Standard for Pipe Threads

E. M. Herr, *Chairman* — Geo. M. Bond
William J. Baldwin — Stanley G. Flagg, Jr

On Thurston Memorial

Alex. C. Humphreys, *Chairman* — Chas. Wallace Hunt
R. C. Carpenter — J. W. Lieb, Jr.
Fred J. Miller

On Hudson-Fulton Celebration

Geo. W. Melville — M. L. Holman
Jesse M. Smith

On Standards for Involute Gears

Wilfred Lewis, *Chairman* — E. R. Fellows
Hugo Bilgram — C. R. Gabriel
Gaetano Lanza

On Power Tests

D. S. Jacobus, *Chairman* — L. P. Breckenridge — Edward F. Miller
Edward T. Adams — William Kent — Arthur West
George H. Barrus — Charles E. Lucke — Albert C. Wood

On Land and Building Fund

Fred J. Miller — James M. Dodge
R. C. McKinney

Nominating Committee

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Walter M. McFarland ..... Pittsburg, Pa.
Morgan Brooks ..... Urbana, Ill.
David Townsend ..... Philadelphia, Pa.
Francis W. Dean ..... Boston, Mass.

SOCIETY REPRESENTATIVES

1909

On John Fritz Medal

HENRY R. TOWNE (1) — F. R. HUTTON (3)
AMBROSE SWASEY (2) — CHAS. WALLACE HUNT (4)

On Board of Trustees United Engineering Societies Building

CHAS. WALLACE HUNT (1) — F. R. HUTTON (2)
FRED J. MILLER (3)

On Library Conference Committee

J. W. LIEB, JR., CHAIRMAN OF THE LIBRARY COMMITTEE OF THE AM. SOC. M. E.

On National Fire Protection Association

JOHN R. FREEMAN — IRA H. WOOLSON

On Joint Committee on Engineering Education

ALEX. C. HUMPHREYS — F. W. TAYLOR

On Government Advisory Board on Fuels and Structural Materials

GEO. H. BARRUS — P. W. GATES
W. F. M. GOSS

On Advisory Board National Conservation Commission

GEO. F. SWAIN — JOHN R. FREEMAN
CHAS. T. MAIN

On Council of American Association for the Advancement of Science

ALEX. C. HUMPHREYS — FRED J. MILLER

NOTE.—Numbers in parentheses indicate length of term in years that the member has yet to serve.

OFFICERS OF THE GAS POWER SECTION

1909

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F. R. Low

SECRETARY

Geo. A. Orrok

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F. R. Hutton
G. I. Rockwood
H. H. Suplee
R. H. Fernald

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Paul Winsor
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H. F. Smith
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